National Defence
Research and Development Branch

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Bureau de recherche et développement

DREA CR/98/438

ETASS IV (NGSP) INTEGRATION REPORT

by

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CONTRACTOR REPORT

Prepared for

Defence Research Establishment Atlantic

Centre de Recherches pour la Défense Atlantique

Canada

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Accepted by : G.L. Hemphill - Contract Scientific Authority

W7707-6-3467/001-HAL
Contract Number

July 1998

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ABSTRACT

The NGSP has been under development by DREA for a number of years. The NGSP hardware and software have reached a level in the development where the next step is the evaluation of the NGSP in real applications. This report describes the integration activity undertaken by CDC to integrate the NGSP into two sonar applications. NGSP was successfully integrated into ETASS and ATAS. ETASS is an existing passive towed array sonar system that was developed by DREA and installed on HMCS NIPIGON. ATASA is an active towed array sonar application developed by CDC under contract with DREA. These applications successfully demonstrated the flexibility and performance of the innovative design of the NGSP.

RÉSUMÉ

Le CRDA développe depuis un certain nombre d'années le NGSP. Le matériel et le logiciel NGSP ont atteint le niveau de développement où il faut maintenant procéder à leur évaluation dans des applications réelles. Le présent rapport décrit l'intégration du NGSP à deux applications sonars, activité entreprise par le CDC. Le NGSP a été intégré avec succès à l'ETASS et à l'ATAS. L'ETASS est un système de surveillance par réseaux remorqués passifs qui a été développé par le CRDA et qui a été installé à bord du NCSM NIPIGON. L'ATAS est une application sonar à activation d'antenne linéaire qui a été développée par le CDC par l'entremise du CRDA. Ces applications ont démontré avec succès la souplesse et les performances de la conception novatrice du NGSP.

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1. Scope

1.1 Identification

This document presents the report of the ETASS IV (NGSP) integration activities undertaken by Computing Devices Canada under contract with Defence Research Establishment Atlantic (DREA). The contract reference is W7707-6-3467/001/HAL. These activities began 15 September 1996 and were completed 31 July 1998.

1.2 Document Overview

The information contained in this document describes the results of the ETASS IV (NGSP) integration activities undertaken as part of the above contract. The activities described in this document include the following:

- ETASS IV code port
- Audio integration
- Advance beamformer integration
- Data Manager review
- FIR filter review
- Match filter load analysis
- Match filter kernel generation investigation
- Time tagging investigation
- Event synchronization investigation
- Dipole array beamformer implementation
- Active towed array sonar application
- NGSP software benchmarking

1.3 Acronyms

The following acronyms are used in this document:

- API Application Program Interface
- AR Array Receiver
- ATASA Active Towed Array Sonar Apllication
- CW Continuous Wave
- DAPS Deployable acoustic projector system
- DM Data Manager
- DP Display Processor
- DPS DAPS Positioning System
- DREA Defence Research Establishment Atlantic
- ETASS Experimental Towed Array Sonar System
- FIR Finite Impulse Response
- FFT Fast Fourier Transform
- FM Frequency Modulation
- GPS Global Positioning System

- HC Hardcopy
- HF High Frequency
- HP Hull Processor
- IPE Integrated Programming Environment
- LAN Local Area Network
- LF Low Frequency
- LFA Low Frequency Active
- MF Medium Frequency
- MFLOPS Mega floating point operations per second
- MOPS Mega operations per second
- NAD Non-acoustic data
- NDI NGSP Data Interface
- NGSP Next Generation Signal Processor
- RMP Recognized Maritime Picture
- SDL Serial Data Link
- SP Signal Processor
- VLF Very Low Frequency

2. Referenced Documents

The following books and publications provided information that is presented in this document:

- IPE reference manual, Array System Computing, 1995
- PRODAT: A Versatile Tool For Spectral Analysis and Display. DREA Technical Communication 92/309
- Procedures for the Acquisition and Processing of Acoustic Data in Real Time using the PRODAT Software Package. DREA Technical Memorandum.
- Development of Tools for Analysis of Narrowband Ambient Noise. Prior Data Sciences, DREA CR/95/438.
- Fundamentals of Bistatic Active Sonar. Underwater Acoustics Data Processing.
- DREA Data File Standard. DREA Technical Communication 87/302
- Object-Oriented Analysis and Design, With Applications. G. Booch. Second Edition. Benjamin/Cummings Publishing Company Inc. Don Mills, Ontario. 1994.

3. ETASS IV Code Port to NGSP

This section describes the results of the ETASS IV signal processing code port to the NGSP and upgrade to a 4 kHz sampling frequency. Figure 3-1 presents the ETASS IV system block diagram. Figure 3-2 presents the ETASS IV (NGSP) system block diagram. The 501 signal processor(SP) and the TASP Controller(TC) were removed from the aft end equipment room on the HMCS Nipigon and the NGSP and the NDI were added up forward in the sonar control room. Signal processing software and non-acoustic processing software was developed for the NGSP. Existing software was modified and new software was developed for the Data Manager and the Display Processors to support the integration of the NGSP.

The modifications made to the Data Manager software include the following. The TASP Controller Interface (TCI) software was removed from the DM software because it was no longer be needed. The DM acoustic data management software was modified to remove support for acoustic data being received from the TC across the TCI and support was added for acoustic data to be received from the SP through the NDI. The DM non-acoustic data management software was modified to remove support for non-acoustic data being sent and received to and from the TC across the TCI and support was added to send and receive non-acoustic data to and from the SP through the NDI. The DM narrowband tracker software was modified to remove support for narrowband track data being received from the TC across the TCI and support was added to receive narrowband track data from the SP through the NDI. The DM narrowband tracker software was modified to remove support for narrowband tracker commands being sent to the TC across the TCI. The DM system health and monitoring software was modified to remove support for monitoring of the TC and TCI and support was added for monitoring the NDI and SP. DM software was developed to support sending and receiving messages across the NGSP Data Interface. DM software was developed to support broadband image processing because this function was performed by the TC in ETASS IV. The TC broadband image processing software was ported to the DM.

The software development environment for the DP was no longer available. As a result the existing DP images for ETASS IV were patched to support the integration of NGSP. DM software was developed to download the patches to the two DPs across two serial lines. The edit function of the DP monitor program was used to install the patches.

The software developed for the NGSP provides the following functionality:

- frame analysis
- aperture analysis
- spatial analysis
- audio analysis
- broadband analysis
- band analysis
- DEMON analysis
- narrowband analysis
- transient analysis

The above listed functionality is described in the following sections. Section 3.1 presents a summary of the signal processing characteristics. Section 3.2 presents the specifications of the signal processing functionality. Section 3.3 describes the SP and DM interface message protocol supported by the NDI.

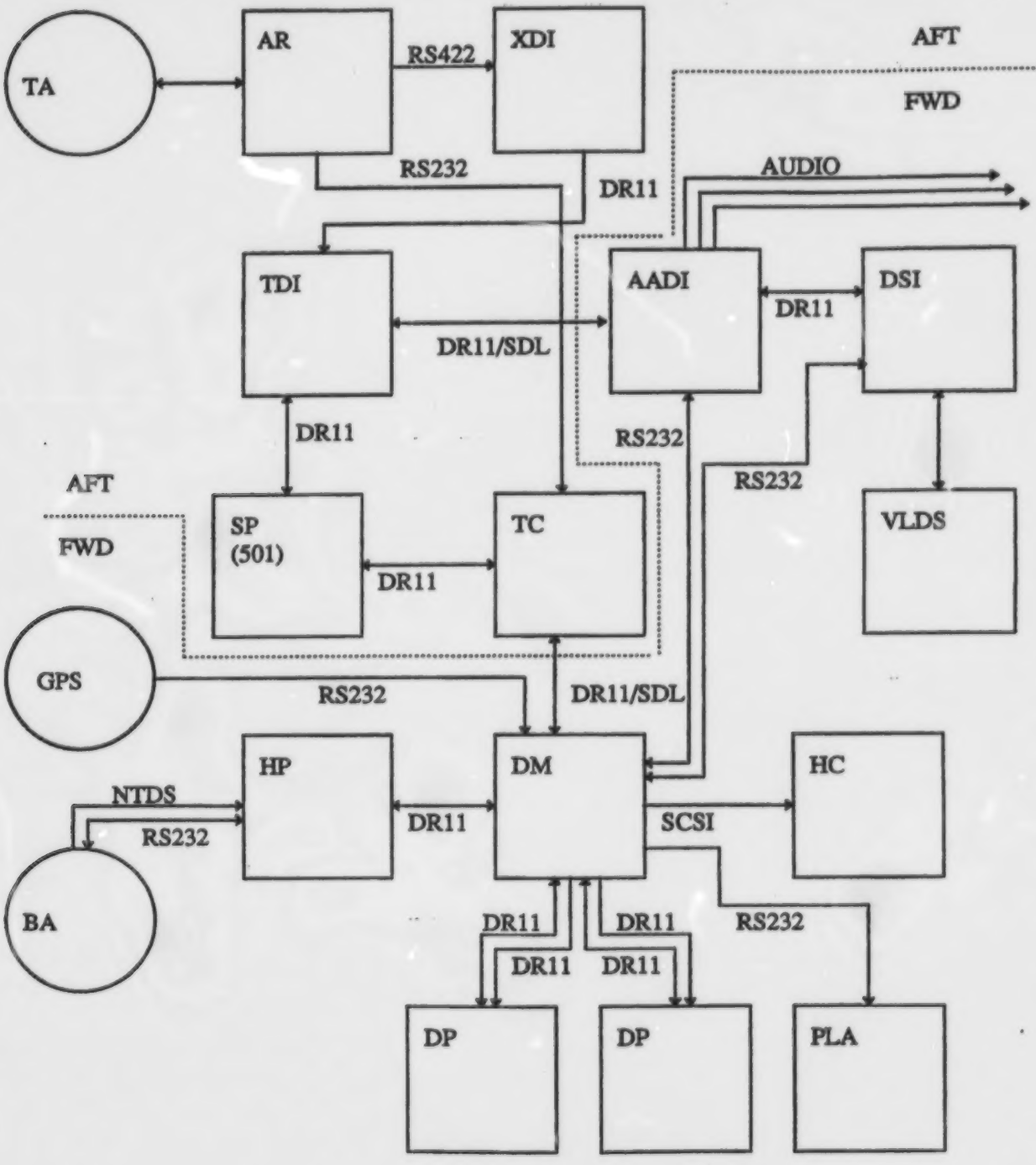


Figure 3-1 ETASS IV System Block Diagram

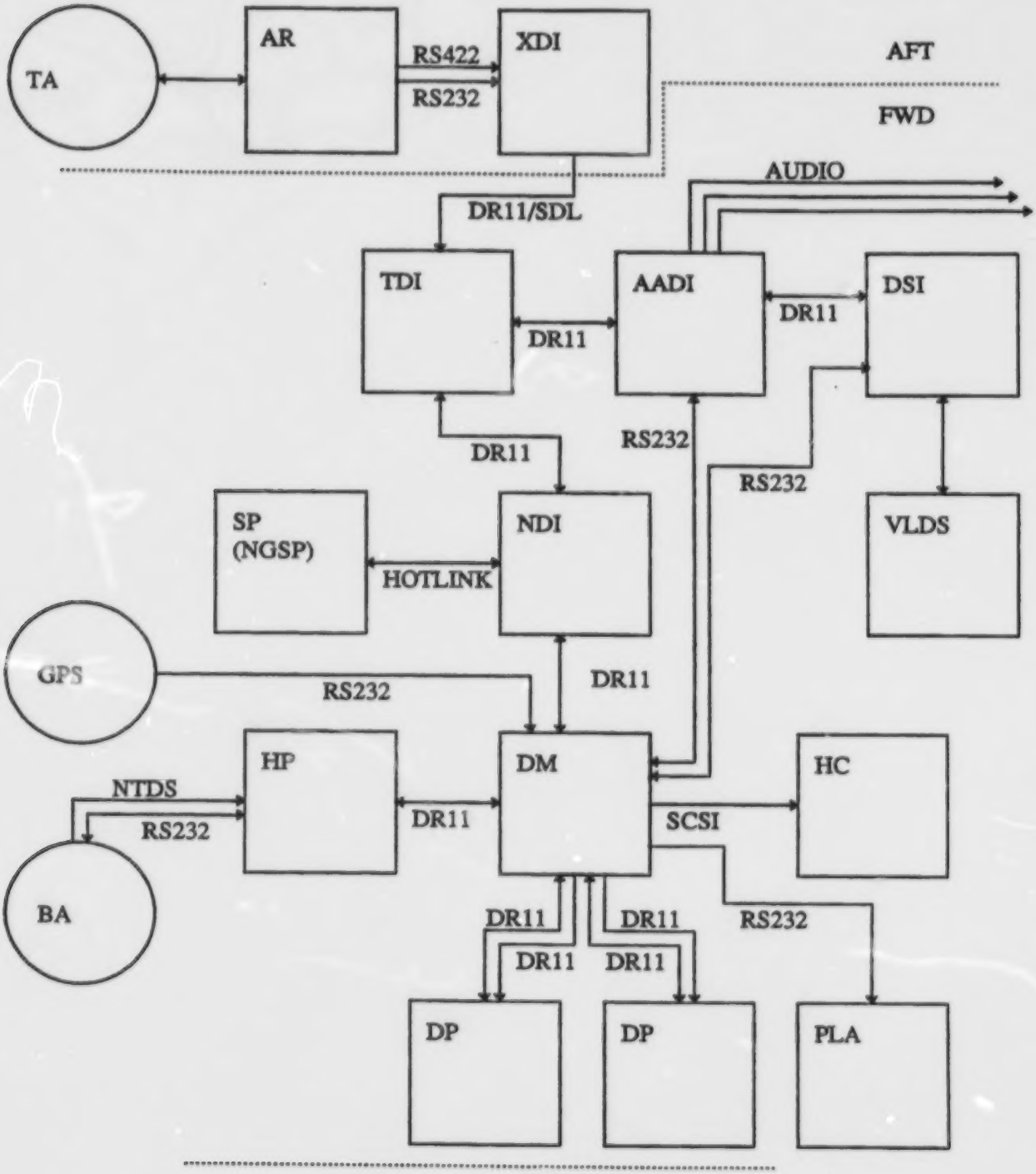


Figure 3-2 ETASS IV (NGSP) System Block Diagram

3.1 Signal Processing Software Characteristics

The ETASS IV (NGSP) signal processing characteristics are summarized as follows:

- conventional beamformer
  - 1 s time window overlapped by 25%
  - 0 - 1400 Hz band (VLF, LF, MF and HF apertures)
  - 48 equally spaced sensors
  - 43 beams equally spaced in cosine space over 180 degrees
- broadband
  - 90 - 1400 Hz band
  - 1.5, 3 and 9 s integration periods
- narrowband
  - 0 - 1400 Hz band
  - 32 s time window (0-175 Hz) overlapped by 75%
  - 16 s time window (175-1400 Hz) overlapped by 50%
  - 0.03125 Hz resolution (0-175 Hz)
  - 0.0625 Hz resolution (175-1400 Hz)
  - 0.5, 0.25, 0.125 and 0.0625 Hz resolutions generated by oring
- audio
  - 90 - 1400 Hz band
  - 3 channels
  - beam or sensor
- demon
  - 175 - 350 Hz band (LF aperture)
  - 8 s time window overlapped by 75%
  - 0.125 Hz resolution
- transient
  - 0 - 1400 Hz band
  - 8 s time window overlapped by 75%
  - 0.125 Hz resolution

3.2 Signal Processing Software Specification

3.2.1 Frame Analysis Specification

- 32 Hz rate
- 256 bytes per frame
- 128 frame block
- extract array time series from array frame
  - convert from integer to floating point
- extract array non-acoustic data from array frame
- concatenate array time series

3.2.2 Aperture Analysis Specification

3.2.2.1 Channel Spectral Analysis

- 0.75 second rate
- 4096 point FFT with 25% overlap
- synthesize -20 to 0 Hz
- VLF channel spectral data from -20 to 212 Hz at 1 Hz resolution
- LF channel spectral data from -20 to 372 Hz at 1 Hz resolution
- MF channel spectral data from -20 to 728 Hz at 1 Hz resolution
- HF channel spectral data from -20 to 1438 Hz at 1 Hz resolution

3.2.2.2 Channel Combination

- 0.75 second rate
- average 24 pairs of adjacent HF channel spectral data over -20 to 728 Hz to form 24 MF channels
- average 24 pairs of adjacent MF channel spectral data over -20 to 372 Hz to form 24 LF channels
- average 24 pairs of adjacent LF channel spectral data over -20 to 212 Hz to form 24 VLF channels

3.2.3 Spatial Analysis Specification

- 0.75 second rate
- Generate 4 apertures of 43 beams spectra equally spaced in cosine space
  - 48 VLF channels from -20 to 212 Hz at 4 m spacing
  - 48 LF channels from 140 to 372 Hz at 2 m spacing
  - 48 MF channels from 328 to 728 Hz at 1 m spacing
  - 48 HF channels from 678 to 1438 Hz at 0.5 m spacing
  - Taylor shaded across 48 channels
  - Variable speed of sound 1450 to 1550 m/s

3.2.4 Audio Analysis Specification

- 0.75 second rate
- 3 beams

- brickwall filter beam spectra
  - 250 -350 Hz from LF beam spectra
  - 350-700 Hz from MF beam spectra
  - 700-1400 Hz from HF beam spectra
- synthesize negative spectra
- 4096 point IFFT
- 4096 Hz real time series
- scale
- convert to 16-bit integer
- concatenate time series to form 3 second buffers

3.2.5 Broadband Analysis Specification

- 0.75 second rate
- beam spectra magnitude from 100 to 1400 Hz
- sum beam spectral magnitudes for each aperture
- weight aperture beam powers
- sum aperture beam powers
- accumulate beam power for 0.75, 1.5, 3.0 and 9.0 seconds

3.2.6 Band Analysis Specification

3.2.6.1 VLF Band Analysis Specification

- 0.75 second rate
- low pass filter VLF beam spectra
  - 500 point low pass FIR
  - 256 Hz sample frequency
  - 0-179 Hz pass band
  - 179-239 Hz transition band
  - heterodyne frequency of 96 Hz
- decimated VLF beam time series
  - 256 point IFFT
  - discard first 64 points
    filter length of 32 points
    array length of 32 points
  - keep next 192 points
  - concatenate time series

3.2.6.2 LF Band Analysis Specification

- 0.75 second rate
- band pass filter LF beam spectra
  - 762 point band pass FIR
  - 256 Hz sample frequency
  - 171-354 Hz pass band
  - 136-171 Hz and 354-383 Hz transition band
  - heterodyne frequency of 256 Hz

- decimated LF beam time series
  - 256 point IFFT
  - discard first 64 points
    filter length of 32 points
    array length of 32 points
  - keep next 192 points
  - concatenate time series

3.2.6.3 MF Band Analysis Specification

- 0.75 second rate
- band pass filter MF beam spectra
  - 892 point band pass FIR
  - 512 Hz sample frequency
  - 346-704 Hz pass band
  - 306-346 Hz and 704-739 Hz transition band
  - heterodyne frequency of 512 Hz
- decimated MF beam time series
  - 512 point IFFT
  - discard first 128 points
    filter length of 64 points
    array length of 64 points
  - keep next 384 points
  - concatenate time series

3.2.6.4 HF Band Analysis Specification

- 0.75 second rate
- band pass filter HF beam spectra
  - 958 point band pass FIR
  - 1024 Hz sample frequency
  - 696-1404 Hz pass band
  - 660-696 Hz and 1404-1440 Hz transition band
  - heterodyne frequency of 1056 Hz
- decimated HF beam time series
  - 1024 point IFFT
  - discard first 256 points
    filter length of 128 points
    array length of 128 points
  - keep next 768 points
  - concatenate time series

3.2.7 DEMON Analysis Specification

3.2.7.1 DEMON Spectral Analysis

- 0.125 Hz resolution
- LF beam time series

- 8 second aperture
- 2 second rate
- 2048 point FFT with 1536 point overlap
- magnitude of spectral power from -4 to 84 Hz

3.2.7.2 DEMON Normalization

- two pass split window normalizer
  - 14-5-14 split window
- normalized power from 0.125 to 79.875 Hz at 0.125 Hz resolution

3.2.7.3 DEMON Resolution Reduction

- or adjacent normalized power bins together
  - sixth root of sum of the sixth order of the two adjacent normalized power bins
- three resolutions
  - 0.25 Hz from 0.25 to 79.75 Hz
  - 0.5 Hz from 0.5 to 79.5 Hz
  - 1.0 Hz from 1 to 79 Hz

3.2.7.4 DEMON Quantization

- scaled logarithmic function
- clip between 0 and 7

3.2.7.5 DEMON Pixelization

- convert to 3 bit pixel
- pack pixel into lower 3 bits of 4 bit nibble
- pack 4 nibbles to 16 bit word

3.2.8 Narrowband Analysis Specification

3.2.8.1 VLF Narrowband Analysis Specification

3.2.8.1.1 VLF Narrowband Spectral Analysis

- 0.03125 Hz resolution
- 32 second aperture of VLF beam time series
- 8 second rate
- 8192 point Hamming window
- 8192 point FFT with 6144 point overlap
- magnitude of spectral power from -1.0 to 176.0 Hz

3.2.8.1.2 VLF Narrowband Normalization

- two pass split window normalizer
  - 14-5-14 split window
- normalized power from 0.03125 to 174.96875 Hz at 0.03125 Hz resolution

3.2.8.1.3 VLF Narrowband Resolution Reduction

- or adjacent normalized power bins together
  - sixth root of sum of the sixth order of the two adjacent normalized power bins
- five resolutions
  - 0.0625 Hz from 0.0625 to 174.9375 Hz
  - 0.125 Hz from 0.125 to 174.875 Hz
  - 0.25 Hz from 0.25 to 174.75 Hz
  - 0.5 Hz from 0.5 to 174.5 Hz
  - 1 Hz from 1 to 174 Hz

3.2.8.1.4 VLF Narrowband Quantization

- scaled logarithmic function
- clip between 0 and 7

3.2.8.1.5 VLF Narrowband Pixelization

- convert to 3 bit pixel
- pack pixel into lower 3 bits of 4 bit nibble
- pack 4 nibbles to 16 bit word

3.2.8.2 LF Narrowband Analysis Specification

3.2.8.2.1 LF Narrowband Spectral Analysis

- 0.0625 Hz resolution
- 16 second aperture of LF beam time series
- 8 second rate
- 4096 point Hamming window
- 4096 point FFT with 2048 point overlap
- magnitude of spectral power from 173.0 to 352.0 Hz

3.2.8.2.2 LF Narrowband Normalization

- two pass split window normalizer
  - 14-5-14 split window
- normalized power from 175.0 to 349.9375 Hz

3.2.8.2.3 LF Narrowband Resolution Reduction

- or adjacent normalized power bins together
  - sixth root of sum of the sixth order of the two adjacent normalized power bins
- four resolutions
  - 0.125 Hz from 175.0 to 349.875 Hz
  - 0.25 Hz from 175.0 to 349.75 Hz
  - 0.5 Hz from 175.0 to 349.5 Hz
  - 1 Hz from 175 to 349 Hz

3.2.8.2.4 LF Narrowband Quantization

- scaled logarithmic function
- clip between 0 and 7

3.2.8.2.5 LF Narrowband Pixelization

- convert to 3 bit pixel
- pack pixel into lower 3 bits of 4 bit nibble
- pack 4 nibbles to 16 bit word

3.2.8.3 MF Narrowband Analysis Specification

3.2.8.3.1 MF Narrowband Spectral Analysis

- 0.0625 Hz resolution
- 16 second aperture of MF beam time series
- 8 second rate
- 8192 point Hamming window
- 8192 point FFT with 4096 point overlap
- magnitude of spectral power from 348.0 to 702.0 Hz

3.2.8.3.2 MF Narrowband Normalization

- two pass split window normalizer
  - 14-5-14 split window
- normalized power from 350.0000 to 699.9375 Hz

3.2.8.3.3 MF Narrowband Resolution Reduction

- or adjacent power bins together
  - sixth root of sum of the sixth order of the two adjacent power bins
- four resolutions
  - 0.125 Hz from 350.000 to 699.875 Hz
  - 0.25 Hz from 350.00 to 699.75 Hz
  - 0.5 Hz from 350.0000 to 699.5 Hz
  - 1 Hz from 350 to 699 Hz

3.2.8.3.4 MF Narrowband Quantization

- scaled logarithmic function
- clip between 0 and 7

3.2.8.3.5 MF Narrowband Pixelization

- convert to 3 bit pixel
- pack pixel into lower 3 bits of 4 bit nibble
- pack 4 nibbles to 16 bit word

3.2.8.4 HF Narrowband Analysis Specification

3.2.8.4.1 HF Narrowband Spectral Analysis

- 0.0625 Hz resolution
- 16 second aperture of HF beam time series
- 8 second rate
- 16384 point Hamming window

- 16384 point FFT with 8192 point overlap
- magnitude of spectral power from 698.0 to 1402.0 Hz

3.2.8.4.2 HF Narrowband Normalization

- two pass split window normalizer
  - 14-5-14 split window
- normalized power from 700.0000 to 1399.9375 Hz

3.2.8.4.3 HF Narrowband Resolution Reduction

- or adjacent power bins together
  - sixth root of sum of the sixth order of the two adjacent power bins
- four resolutions
  - 0.125 Hz from 700.000 to 1399.875 Hz
  - 0.25 Hz from 700.00 to 1399.75 Hz
  - 0.5 Hz from 700.0 to 1399.5 Hz
  - 1 Hz from 700 to 1399 Hz

3.2.8.4.4 HF Narrowband Quantization

- scaled logarithmic function
- clip between 0 and 7

3.2.8.4.5 HF Narrowband Pixelization

- convert to 3 bit pixel
- pack pixel into lower 3 bits of 4 bit nibble
- pack 4 nibbles to 16 bit word

3.2.9 Transient Analysis Specification

3.2.9.1 VLF Transient Analysis Specification

3.2.9.1.1 VLF Transient Spectral Analysis

- 0.125 Hz resolution
- 8 second aperture of VLF beam time series
- 2 second rate
- 2048 point Hamming window
- 2048 point FFT with 1536 point overlap
- magnitude of spectral power from -4 to 179 Hz

3.2.9.1.2 VLF Transient Normalization

- two pass split window normalizer
  - 14-5-14 split window
- normalized power from 0.125 to 174.875 Hz at 0.125 Hz resolution

3.2.9.1.3 VLF Transient Resolution Reduction

- or adjacent normalized power bins together

- sixth root of sum of the sixth order of the two adjacent normalized power bins
- three resolutions
  - 0.25 Hz from 0.25 to 174.75 Hz
  - 0.5 Hz from 0.5 to 174.5 Hz
  - 1.0 Hz from 1 to 174 Hz

3.2.9.1.4 VLF Transient Quantization

- scaled logarithmic function
- clip between 0 and 7

3.2.9.1.5 VLF Transient Pixelization

- convert to 3 bit pixel
- pack pixel into lower 3 bits of 4 bit nibble
- pack 4 nibbles to 16 bit word

3.2.9.2 LF Transient Analysis Specification

3.2.9.2.1 LF Transient Spectral Analysis

- 0.125 Hz resolution
- 8 second aperture of LF beam time series
- 2 second rate
- 2048 point Hamming window
- 2048 point FFT with 1538 point overlap
- magnitude of spectral power from 171 to 354 Hz

3.2.9.2.2 LF Transient Normalization

- two pass split window normalizer
  - 14-5-14 split window
- normalized power from 175.00 to 349.875 Hz at 0.125 Hz resolution

3.2.9.2.3 LF Transient Resolution Reduction

- or adjacent normalized power bins together
  - sixth root of sum of the sixth order of the two adjacent normalized power bins
- three resolutions
  - 0.25 Hz from 175.00 to 349.75 Hz
  - 0.5 Hz from 175.0 to 349.5 Hz
  - 1.0 Hz from 175 to 349 Hz

3.2.9.2.4 LF Transient Quantization

- scaled logarithmic function
- clip between 0 and 7

3.2.9.2.5 LF Transient Pixelization

- convert to 3 bit pixel
- pack pixel into lower 3 bits of 4 bit nibble

- pack 4 nibbles to 16 bit word

3.2.9.3 MF Transient Analysis Specification

3.2.9.3.1 MF Transient Spectral Analysis

- 0.125 Hz resolution
- 8 second aperture of MF beam time series
- 2 second rate
- 4096 point Hamming window
- 4096 point FFT with 3072 point overlap
- magnitude of spectral power from 346 to 704 Hz

3.2.9.3.2 MF Transient Normalization

- two pass split window normalizer
  - 14-5-14 split window
- normalized power from 350.000 to 699.875 Hz at 0.125 Hz resolution

3.2.9.3.3 MF Transient Resolution Reduction

- or adjacent normalized power bins together
  - sixth root of sum of the sixth order of the two adjacent normalized power bins
- three resolutions
  - 0.25 Hz from 350.00 to 699.75 Hz
  - 0.5 Hz from 350.0 to 699.5 Hz
  - 1.0 Hz from 350 to 699 Hz

3.2.9.3.4 MF Transient Quantization

- scaled logarithmic function
- clip between 0 and 7

3.2.9.3.5 MF Transient Pixelization

- convert to 3 bit pixel
- pack pixel into lower 3 bits of 4 bit nibble
- pack 4 nibbles to 16 bit word

3.2.9.4 HF Transient Analysis Specification

3.2.9.4.1 HF Transient Spectral Analysis

- 0.125 Hz resolution
- 8 second aperture of HF beam time series
- 2 second rate
- 8192 point Hamming window
- 8192 point FFT with 6144 point overlap
- magnitude of spectral power from 696 to 1404 Hz

3.2.9.4.2 HF Transient Normalization

- two pass split window normalizer
  - 14-5-14 split window
- normalized power from 700.000 to 1399.875 Hz at 0.125 Hz resolution

3.2.9.4.3 HF Transient Resolution Reduction

- or adjacent normalized power bins together
  - sixth root of sum of the sixth order of the two adjacent normalized power bins
- three resolutions
  - 0.25 Hz from 700.00 to 1399.75 Hz
  - 0.5 Hz from 700.5 to 1399.5 Hz
  - 1.0 Hz from 700 to 1399 Hz

3.2.9.4.4 HF Transient Quantization

- scaled logarithmic function
- clip between 0 and 7

3.2.9.4.5 HF Transient Pixelization

- convert to 3 bit pixel
- pack pixel into lower 3 bits of 4 bit nibble
- pack 4 nibbles to 16 bit word

3.3 Signal Processing Design

This section presents the objected oriented design for the ETASS IV (NGSP) signal processing software.

The frame analysis class supports the extraction of the time series data and the non-acoustic data from the input array data. The processing performed by this class is defined by the following attributes:

- input array data
- output time series

The aperture analysis class overlaps and concatenates the input time series until enough time series is available to generate the output spectra. The processing performed by this class is defined by the following attributes:

- input time series
- overlap points
- output spectra

The spatial analysis class beamforms the input spectra into the output. The processing performed by this class is defined by the following attributes:

- input spectra
- shading coefficients
- output spectra

The band analysis class performs frequency domain bandpass filtering and heterodyning of the input spectra and generates output time series. The processing performed by this class is defined by the

following attributes:

- input spectra
- heterodyne point
- filter spectra
- filter discard and keep points
- output time series
-

The narrowband analysis class supports the spectral analysis of the input time series. The processing performed by this class is defined by the following attributes:

- input time series
- window time series
- overlap points
- spectra keep and discard points
- integration factor
- quantization scale and offset
-

The transient analysis class supports the spectral analysis of the input time series. The processing performed by this class is defined by the following attributes:

- input time series
- overlap points
- spectra keep and discard points
- integration factor
- quantization scale and offset

The demon analysis class supports the spectral analysis of the magnitude of the input time series. The processing performed by this class is defined by the following attributes:

- input time series
- overlap points
- spectra keep and discard points
- integration factor
- quantization scale and offset

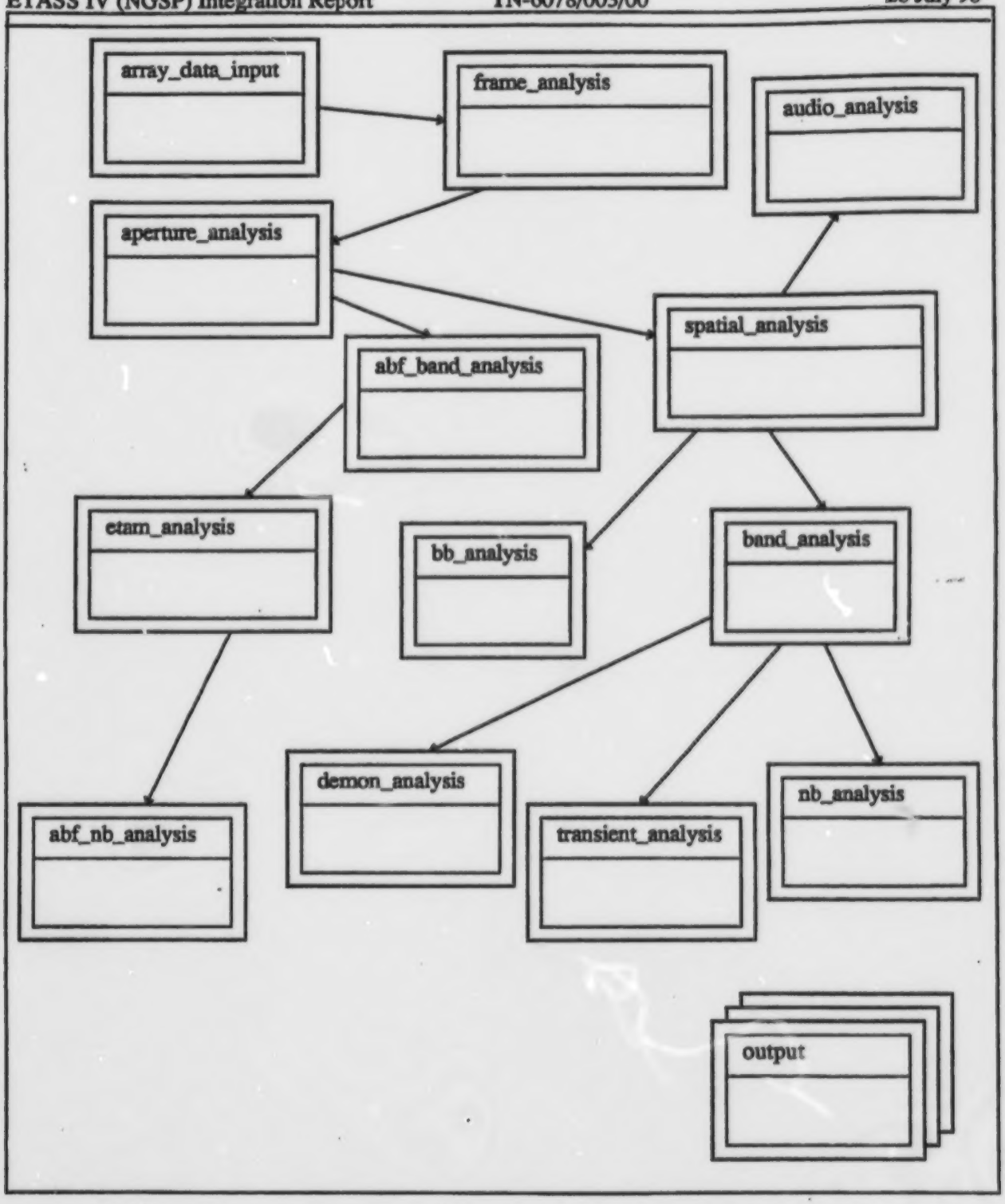


Figure 3-2 ETASS IV (NGSP) Signal Processing Object Interaction

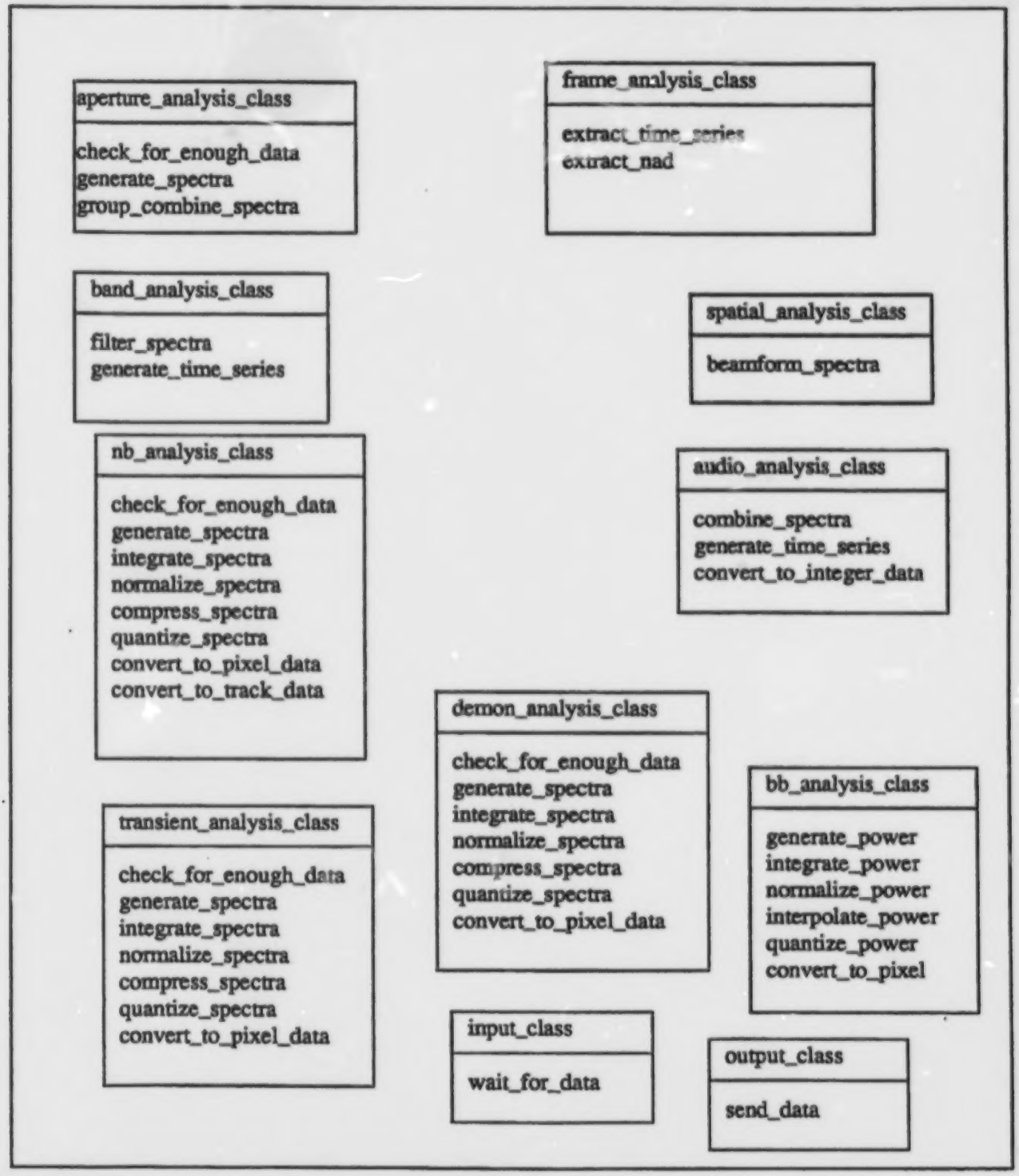


Figure 3-3 ETASS IV (NGSP) Signal Processing Class Operations

3.4 Signal Processor and Data Manager Interface

The Signal Processor and Data Manager interface is an asynchronous bidirectional interface between the NGSP and the DM through the NDI. The physical interface between the NDI and the NGSP is a Hotlink serial interface. This interface supports the transfer of single control words and multiple data words. The basic size of control word transfers across this interface is a 32-bit word. The basic size of data word transfers across this interface is a 64-bit word. The physical interface between the NDI and the DM is a DR11 16-bit parallel interface. The basic size of all transfers across this interface is a 16-bit word. This interface supports single word transfers and multiple word DMA transfers.

The Signal Processor and Data Manager interface supports a set of predefined messages which are used to define and control user defined messages. A message must be defined before it is transferred. The length of a message is fixed once it is defined. Messages are sent to or received from the NDI or passed through the NDI to or from the NGSP, the DM or the TDI. Each message will consist of a message header and an optional message body. The NDI and NGSP interface message header will consist of a 32-bit word comprising a 10-bit message identifier field, a 3-bit destination identifier field, a 3-bit source identifier field and a 16-bit unused filed. The DM and NGSP interface message header will consist of a 16-bit word comprising a 10-bit message identifier field and a 3-bit destination identifier field and a 3-bit source identifier field. The message identifier field will occupy bits 0-9 of the message header. The destination field will occupy bits 10-12 of the message header. The source field will occupy bits 13-15 of the message header. The message identifier identifies the message type, the destination identifier identifies the destination of the message and the source identifier identifies the source of the message. The message body will consist of a number of 64-bit words. The message header will be sent as a control word and the message body will be sent as data words across the NDI and NGSP interface. The message header will be sent in word mode and the message body will be sent in DMA mode across the NDI and DM interface.

The message identifiers of the predefined messages are:

- Status message STATUS_ID 1
- Ready message READY_ID 2
- Path Test message PATH_TEST_ID 3
- Definition message DEFINITION_ID 4
- Definition Status message DEFINITION_STATUS_ID 5
- Delete message DELETE_ID 6
- Delete Status message DELETE_STATUS_ID 7

The range of user defined message identifiers is 10 to 4095.

The destination and source identifiers are:

- NDI NDI_ID 0
- TDI TDI_ID 1
- NGSP SP_ID 2
- DM DM_ID 3

In a typical application, the NGSP and DM would communicate using a set of user defined messages. Each message type requires a unique message identifier and is a fixed length. The same message type can be used in either direction. For each message type, either the NGSP or the DM must send a Definition

message to the NDI before the message can be sent.

3.4.1 Status Message

- Header
  - Identifier — STATUS_ID
- Body
  - Identifier — identifier of received message
  - Status
    - bit 0 — undefined identifier

A Status Message is sent to a message originator when a message with an undefined identifier is received. The identifier field contains the identifier of the received message and bit 0 of the status field is set.

3.4.2 Ready Message

- Header
  - Identifier — READY_ID
- Body
  - Status
    - bit 0 — cold boot
    - bit 1 — warm boot

A Ready Message is sent to indicate that the originator has been booted and is ready to receive messages.

3.4.3 Path Test Message

- Header
  - Identifier — PATH_TEST_ID
- Body
  - Test Data

0X0706050403020100
0X0F0E0D0C0B0A0908
0X1716151413121110
0X1F1E1D1C1B1A1918
.
.
.
0XFFFEFDFCFBFAF9F8

A Path message is a diagnostic message with a 32 64-bit word fixed pattern in the message body. The Path Test message can be used to test a single interface in one direction, a single interface in both directions and two interfaces in one direction by specifying various destination identifiers in the message header.

3.4.4 Definition Message

- Header

- Identifier — DEFINITION_ID
- Body
  - Identifier — identifier
  - Length — number of 64-bit words in message body

The Definition message provides the details of a requested user defined message. The receiver will determine if the Definition message is valid and then send a Definition Status message to the sender.

3.4.5 Definition Status Message

- Header
  - Identifier — DEFINITION_STATUS_ID
- Body
  - Identifier — user defined message identifier
  - Length — number of 64-bit words in message body
  - Status
    - bit 1 — identifier out of range
    - bit 2 — identifier in use
    - bit 3 — length error

A Definition Status message is sent to a message originator when a Definition message is received. The identifier field contains the identifier of the user defined message. The length field contains the 64-bit word length of the user defined message body. Bit 1 of the status field is set if the identifier was out of range of valid user defined message identifiers. Bit 2 of the status field is set if the identifier is in use already. Bit 3 of the status field is set if the length was not a valid message length. If any of bits 1,2 or 3 are set then the message definition was not valid and the user message was not defined.

3.4.6 Delete Message

- Header
  - Identifier — DELETE_ID
- Body
  - Identifier — user defined message identifier

The Delete message requests that the definition of the specified user define message be deleted. The identifier field of the message body contains the user message identifier to be deleted. The receiver will determine if the Delete message is valid and then send a Delete Status message to the sender.

3.4.7 Delete Status Message

- Header
  - Identifier — DELETE_STATUS_ID
- Body
  - Identifier — user defined message identifier
  - Status
    - bit 0 — undefined identifier
    - bit 1 — identifier out of range

A Delete Status Message is sent to a message originator when a Delete message is received. The

identifier field contains the user message identifier deleted. Bit 0 of the status field is set if the specified identifier was defined. Bit 1 of the status field is set if the identifier was out of range of valid user defined message identifiers.

3.4.8 User Defined Messages

The message identifiers of the user defined messages are:

- ARRAY_DATA_ID 10
- AUDIO_ID 11
- SYSTEM_DATA_ID 12
- BROADBAND_1_DATA_ID 13
- BROADBAND_2_DATA_ID 14
- BROADBAND_3_DATA_ID 15
- BROADBAND_4_DATA_ID 16
- DEMON_0_PIXEL_DATA_ID 17
- DEMON_1_PIXEL_DATA_ID 18
- DEMON_2_PIXEL_DATA_ID 19
- DEMON_3_PIXEL_DATA_ID 20
- TRANSIENT_0_PIXEL_DATA_ID 21
- TRANSIENT_1_PIXEL_DATA_ID 22
- TRANSIENT_2_PIXEL_DATA_ID 23
- TRANSIENT_3_PIXEL_DATA_ID 24
- NARROWBAND_0_PIXEL_DATA_ID 25
- NARROWBAND_1_PIXEL_DATA_ID 26
- NARROWBAND_2_PIXEL_DATA_ID 27
- NARROWBAND_3_PIXEL_DATA_ID 28
- NARROWBAND_4_PIXEL_DATA_ID 29
- NARROWBAND_5_PIXEL_DATA_ID 30
- NARROWBAND_TRACK_DATA_ID 31

3.4.8.1 Array Data

- 32,768 byte superframe at 32 Hz
  - 2,048 byte header
    - sequence count
    - check words
    - time
    - array heading
    - array depth
    - tow cable scope
    - water temperature
    - array sync status
    - array shunt current
    - array voltage
    - array mode
    - array gain

- 128 frames of 120 channels 16 bit 2's complement time series
  - 24 VLF channels
  - 24 LF channels
  - 24 MF channels
  - 48 HF channels

3.4.8.2 System Data

- 0.5 second rate
- 256 bytes of data including
  - sequence number
  - time
  - time count
  - ship heading
  - ship speed
  - latitude
  - longitude
  - array heading
  - audio bearing[3]
  - speed of sound
  - array depth
  - tow cable scope
  - water temperature
  - array sync status
  - array shunt current
  - array voltage
  - array mode
  - array gain
  - salinity

3.4.8.3 Audio Data

- 1.5 second rate
- 3 channels of 6,144 16-bit 2's complement integers
- 36,864 bytes
- 4,608 WM words

3.4.8.4 Broadband Data

- 0.75, 1.5, 3.0 and 9.0 second rate
- 176 bytes
  - 43 32-bit beam powers
- 22 WM words

3.4.8.5 DEMON Data

3.4.8.5.1 DEMON 0 Data

- 2 second rate

- 1,720 bytes of acoustic data including:
  - 43 beams of 80 4-bit pixels
- 217 WM words

3.4.8.5.2 DEMON 1 Data

- 2 second rate
- 3,440 bytes of acoustic data including:
  - 43 beams of 80x2 4-bit pixels
- 432 WM words

3.4.8.5.3 DEMON 2 Data

- 2 second rate
- 6,880 bytes of acoustic data including:
  - 43 beams of 80x4 4-bit pixels
- 860 WM words

3.4.8.5.4 DEMON 3 Data

- 2 second rate
- 13,760 bytes of acoustic data including:
  - 43 beams of 80x8 4-bit pixels
- 1,720 WM words

3.4.8.6 Narrowband Data

3.4.8.6.1 Narrowband 0 Data

- 8 second rate
- 30,272 bytes of acoustic data including:
  - 43 beams of 1,400 4-bit pixels
- 3,786 WM words

3.4.8.6.2 Narrowband 1 Data

- 8 second rate
- 60,200 bytes of acoustic data including:
  - 43 beams of 1,400x2 4-bit pixels
- 7,527 WM words

3.4.8.6.3 Narrowband 2 Data

- 8 second rate
- 120,400 bytes of acoustic data including:
  - 43 beams of 1,400x4 4-bit pixels
- 15,050 WM words

3.4.8.6.4 Narrowband 3 Data

- 8 second rate
- 240,800 bytes of acoustic data including:

- 43 beams of 1,400x8 4-bit pixels
- 30,100 WM words

3.4.8.6.5 Narrowband 4 Data

- 8 second rate
- 481,600 bytes of acoustic data including:
  - 43 beams of 1,400x16 4-bit pixels
- 60,200 WM words

3.4.8.6.6 Narrowband 5 Data

- 8 second rate
- 120,400 bytes of acoustic data including:
  - 43 beams of 1400x32 4-bit pixels
- 15,050 WM words

3.4.8.6.7 Narrowband Track Data

- 8 second rate
- 1,926,400 bytes of acoustic data including:
  - 43 beams of 1400x8 32-bit floating point numbers
- 240,800 WM words

3.4.8.7 Transient Data

3.4.8.7.1 Transient 0 Data

- 2 second rate
- 30,272 bytes of acoustic data including:
  - 43 beams of 1400 4-bit pixels
- 3,786 WM words

3.4.8.7.2 Transient 1 Data

- 2 second rate
- 60,200 bytes of acoustic data including:
  - 43 beams of 1400x2 4-bit pixels
- 7,527 WM words

3.4.8.7.3 Transient 2 Data

- 2 second rate
- 120,400 bytes of acoustic data including:
  - 43 beams of 1400x4 4-bit pixels
- 15,050 WM words

3.4.8.7.4 Transient 3 Data

- 2 second rate
- 240,800 bytes of acoustic data including:
  - 43 beams of 1400x8 4-bit pixels

- 30,100 WM words

4. Audio Integration

This section describes the results of the integration of an audio capability into ETASS IV (NGSP). The audio functionality for ETASS IV (NGSP) provides three independent channels of audio across the VLF, LF, MF and HF apertures steered along any beam direction or omni-directional from any channel selected by the operators.

The DM software was modified to send audio control messages to the SP through the NDI. SP software was developed to receive audio control messages from the NDI, provide beam selectable full-bandwidth audio processing and send audio data to the AADI through the NDI. In order to reuse as much non SP software as possible, the audio processing software generates six second audio output blocks as supported by the AADI.

The audio processing software combines the selected beam or channel 1 Hz spectra from the four apertures into three composite spectra. Each composite spectra is transformed into a real time series without filtering. The real time series is concatenated to collect six seconds of data and then scaled, converted to 16-bit integer and sent to the AADI. Refer to section 3.2.4 of this document for specification of the audio processing.

5. Integration of Advance Beamforming Algorithms

This section describes the results of the integration of the advance beamforming algorithms into ETASS IV(NGSP). The original implementations of these algorithms in the IPE were done by another contractor and were written for a workstation environment and not the NGSP. The ETAM-NB, STMV-BB and MVDR-BB adaptive beamforming algorithms were rewritten and optimized for the NGSP and integrated into ETASS IV (NGSP). As part of this activity, the DM data management software was modified to support concurrent reception, storage and display of the conventional display data and the adaptive display data. The DM tracker software was modified to support trackers using tracking data from either conventional processing or adaptive processing in order to compare the performance of the adaptive beamforming algorithms. This algorithms were tested with real data including evaluation at sea. The results were inconclusive as to whether this algorithms provide any detection performance improvement.

6. Data Manager Review

The ETASS Data Manager provided many unrelated functions as identified in the following list:

- Acoustic data management
- System data management
- Marker data management
- Pixel cache management
- Hardcopy management
- Signal Tracking
- Broadband interpolation
- Broadband stabilization
- Hull Processor Interface

- NDI Interface
- Display Processor Interface
- Pixel Cache Interface
- GPS Interface
- Data recorder Interface
- Hardcopy Interface
- System Data Interface

These functions were implemented in C and assembler and the program executed on 68020 and 68030 processors in a VME environment using the VRTX real time executive for process scheduling and inter-process communications. The development environment for this code was primitive compared to the tools that are currently available and the computational power of the processors was only a fractional of the processors that are currently available. As a consequence software maintenance and integration testing for the Data Manager program was difficult and expensive.

In future developments the Data Manager will be replaced by a collection of independent data servers distributed across several processors interconnected by one or more high bandwidth networks. Clients will access the data servers locally or across the networks through well defined application program interfaces(API). The data servers will not necessarily be tied to a particular hardware component, but will be able to run on various hardware components to support partial or full system configurations. The software development environments and the runtime environments will be based on the flexible UNIX workstation architectures that are currently available. This will simplify software development, leverage existing software, speed up system integration and reduce software maintenance costs. In some cases the general operating systems approach might not provide the required performance and a real time operating system such as VXWorks might be needed to support a particular function.

Figure 6-1 presents a possible system configuration for a future active passive sonar system. Two local area networks are used to split the bandwidth requirements if necessary. Typically the preprocessed data and postprocessed data do not have overlapping producers and consumers - data recording being an exception. The functional elements identified represent functional components and not hardware components. A typical application might allocate one or more functional components to a single hardware component.

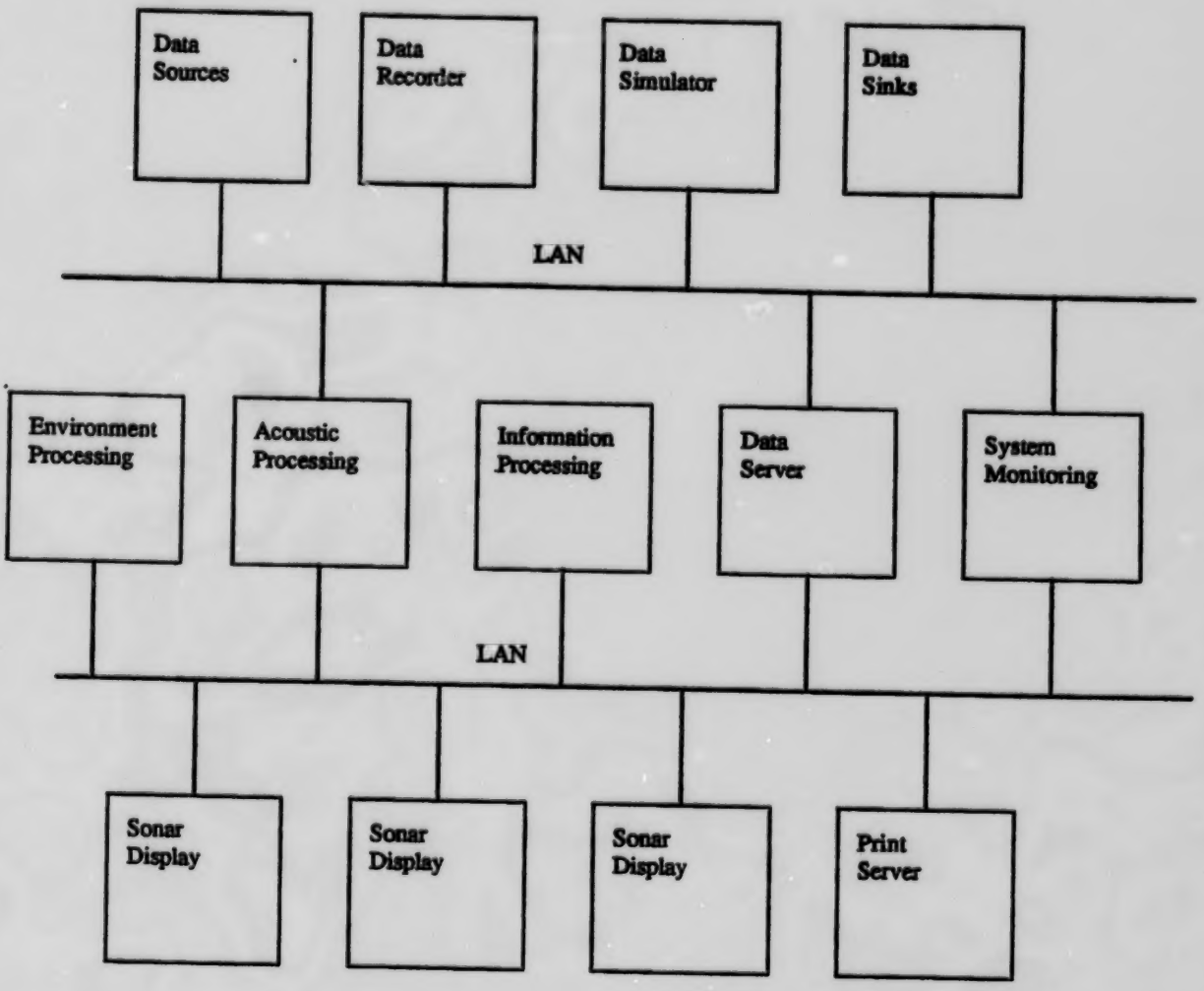


Figure 6-1 Sonar Functional Block Diagram

The following list presents a more detailed functional decomposition of the components identified in figure 6-1.

- Data Sources
  - array data receiver
    - distributes array acoustic time series data to subscribers
    - distributes array non-acoustic data to subscribers
    - control array gain
  - amplifier data
  - transmitter data
  - GPS data receiver
  - bathy data receiver
  - Ownship data receiver
  - JMCIS receiver
    - distributes tactical data to subscribers
    - distrbutes ping messages to subscribers
- Data Recorder
  - controls recorder
  - receives data from all sources in record
  - distributes recorded data to subscribers in playback
- Data Simulator
  - simulates and distributes array acoustic time series data
  - simulates and distributes array non-acoustic data
  - simulates and distributes tactical data
- Data Sinks
  - Acoustic transmitter
    - Controls transmitter amplifiers
    - Generates wavetrains and waveforms
    - Distributes wavetrain and waveform definitions
  - JMCIS transmitter
    - collects and sends messages to JMCIS/CCCS
  - Audio transmitter

- Data Server
  - Store, respond to queries and distribute to subscribers the following data:
    - Array Time Series Data
    - Acoustic Data
    - Signal Data
    - Contact Data
    - Target Data
    - Tactical Data
      - JMCIS RMP
    - Propagation Data
    - Reverberation Data
    - Environmental Data
      - speed of sound profiles
    - Bottom Profile Data
    - System Data
      - time of day - various sources
      - array non-acoustic data
      - transmitter non-acoustic data
      - amplifier non-acoustic data
      - winch non-acoustic data
      - speed of sound - various sources
      - magnetic declination - various sources
    - Coastline Data
    - Chart Data
    - System Configuration Data
      - wavetrain schedule
      - wavetrain definitions
      - waveform definitions
      - acoustic processing configuration
      - environmental processing configuration
      - information processing configuration
      - display configuration
    - System Monitoring Data
- Information Processing
  - signal manager
  - contact manager
  - target manager
- Environment Processing
  - bathy processing
  - propagation modelling
  - reverberation modelling

- Acoustic Processing
  - Array analysis
  - Passive analysis
  - CW analysis
  - FM analysis
  - Audio analysis
  - Broadband analysis
  - DEMON analysis
  - Transient analysis
  - Explosive echo ranging analysis
- System Monitoring
  - Error reporting
  - Processor utilization
  - Network utilization
  - Interface utilization

7. FIR Filter Design Review

This section presents the FIR filter implementations for ETASS IV (NGSP). ETASS IV implemented spectral filters by designing a low pass filter for half the desired pass band and reflecting the filter around the heterodyne bin to cover the full pass band. These filters were designed in the early 1980's and pushed the limits of the filter design utilities. The low pass filters were designed using a filter length of 246 (limit of utility). The heterodyne bins are typically not centered in the pass band. Consequently, the pass bands were wider than necessary. This squeezed the transition bands, which lowered the stop band attenuation. As well, additional processing was required to beamform the wider transition and pass bands. Current filter design tools provide band pass design capability using double precision numeric calculations and no filter length restriction. The filters presented in this section were designed using the Remez linear-phase FIR filter design utility of MATLAB version 4.2c.1. A design goal was to achieve greater than 150 dB stop band attenuation and less than 0.1 dB pass band ripple. Note the MATLAB utilities perform calculations in double precision, whereas the NGSP performs all calculations in single precision. As a result the calculation performed on the NGSP will not provide better than 100 dB sensitivity.

The lengths of the various processing apertures are:

- VLF 192 m
- LF 96 m
- MF 48 m
- HF 24 m

Assume the range of the speed of sound is 1490 to 1530 m/s. The maximum travel time across the various apertures are:

- VLF 128 ms
- LF 64 ms
- MF 32 ms
- HF 16 ms

The signal processing will overlap the time series by 250 ms. The filter delay and the travel time across each aperture cannot exceed this time. The maximum filter delays are:

- VLF 122 ms

- LF 186 ms
- MF 218 ms
- HF 234 ms

The sampling frequency is 4096 Hz. The maximum filter lengths for the various apertures are:

- VLF 500
- LF 762
- MF 892
- HF 958

7.1 VLF Low Pass Filter

The VLF band is filtered and transformed into a 256 Hz time series. The transition bands and pass band are constrained to a 256 Hz band. The VLF pass band is 0 to 179 Hz.

The MATLAB script used to design the VLF low pass filter is:

```
# generate FIR low pass filter points
n=500;
m=[ 1 1 0 0 ];
f = [ 0 179/4096 239/4096  1];
b = remez(n,f,m);

# save to file
fid = fopen( 'firVLF.txt', 'w' );
fprintf( fid, '   %16.8e,\n',b);
fclose(fid);

# plot frequency response
[H,w]=freqz(b);
plot( 4096*w/pi,20*log(abs(H)))
grid on

# plot pass band ripple
axis( [ 0 255  -0.5 0.5 ] )
```

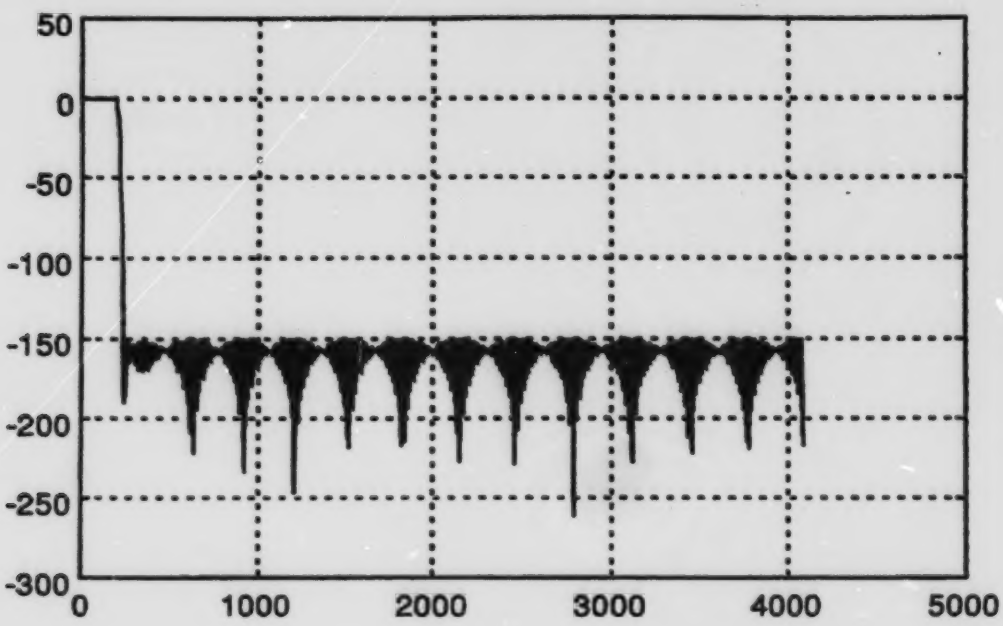


Figure 7-1 VLF Low Pass Filter Frequency Response

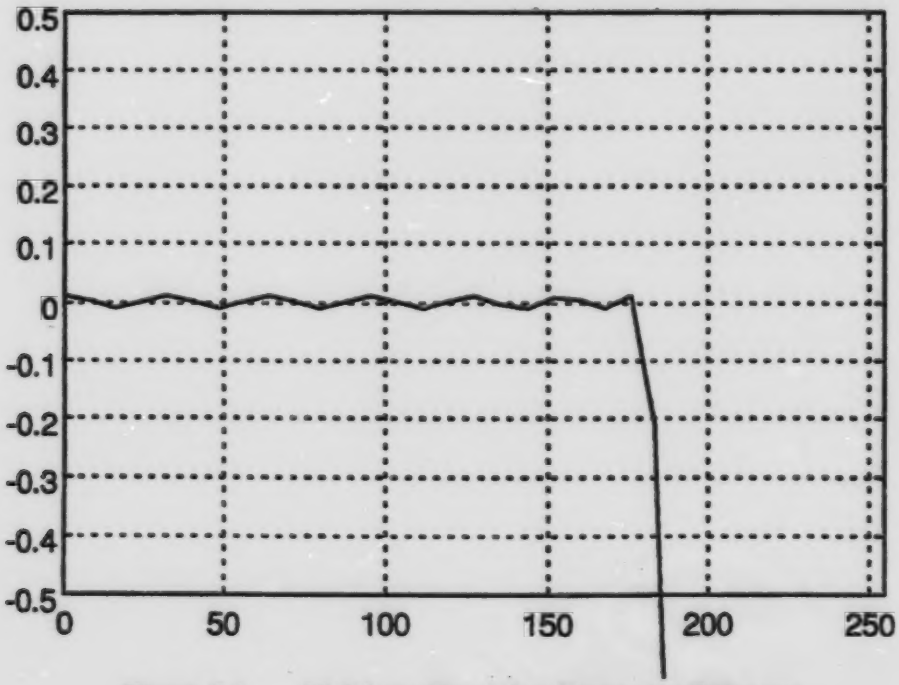


Figure 7-2 VLF Low Pass Filter Frequency Response

7.2 LF Band Pass Filter

The LF band is filtered and transformed into a 256 Hz time series. The transition bands and pass band are constrained to a 256 Hz band. The LF pass band is 171 to 354 Hz.

The MATLAB script used to design the LF low pass filter is:

```
#generate FIR band pass filter points
n=762;
m=[ 0 0 1 1 0 0 ];
f = [ 0 136/4096 171/4096 354/4096 383/4096 1];
b = remez(n,f,m);

#save to file
fid = fopen( 'firLF.txt', 'w' );
fprintf( fid, '   %16.8e,\n',b);
fclose(fid);

# plot frequency response
[H,w]=freqz(b);
plot( 4096*w/pi,20*log(abs(H)))
grid on

# plot pass band ripple
axis( [ 128 383  -0.5 0.5 ] )
```

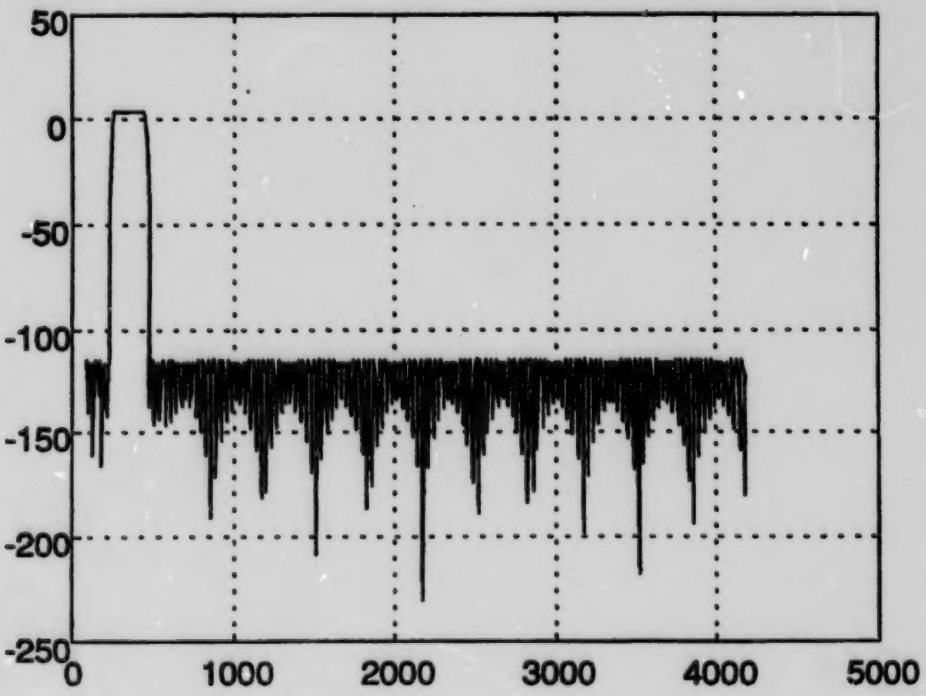


Figure 7-3 LF Band Pass Filter Frequency Response

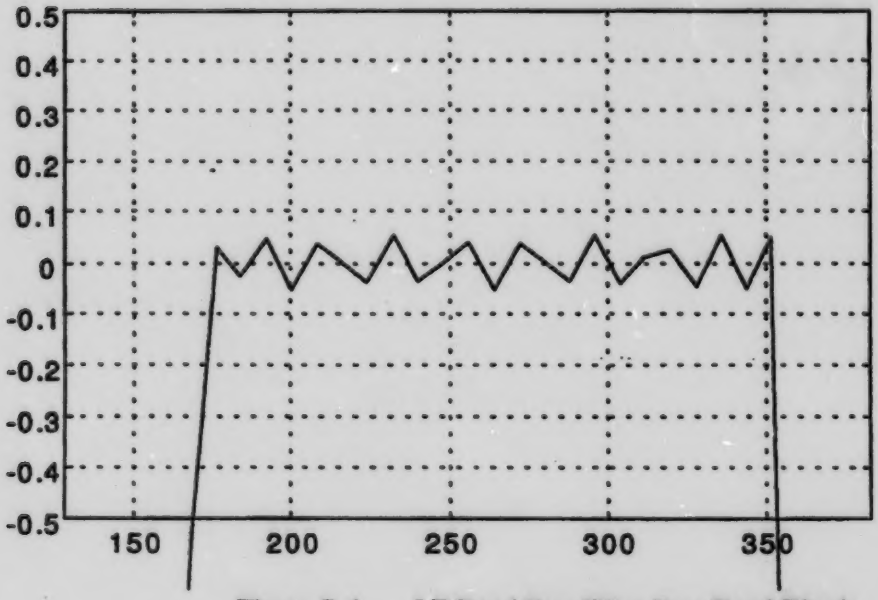


Figure 7-4 LF Band Pass Filter Pass Band Ripple

7.3 MF Aperture Filter

The MF band is filtered and transformed into a 512 Hz time series. The transition bands and pass band are constrained to a 512 Hz band. The MF pass band is 346 to 704 Hz.

The MATLAB script used to design the MF low pass filter is:

```
n=892;
m=[ 0 0 1 1 0 0 ];
f = [ 0 306/4096 346/4096 704/4096 739/4096 1];
b = remez(n,f,m);

#save to file
fid = fopen( 'firMF.txt', 'w' );
fprintf( fid, '   %16.8e,\n',b);
fclose(fid);

# plot frequency response
[H,w]=freqz(b);
plot( 4096*w/pi,20*log(abs(H)))
grid on

# plot pass band ripple
axis( [ 256 767 -0.5 0.5 ] )
```

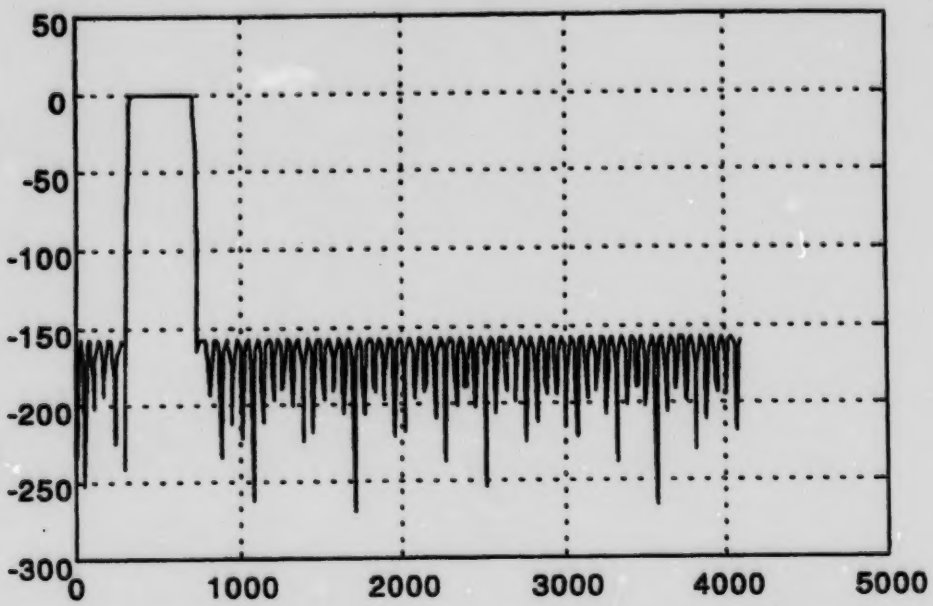


Figure 7-5 MF Band Pass Filter Frequency Response

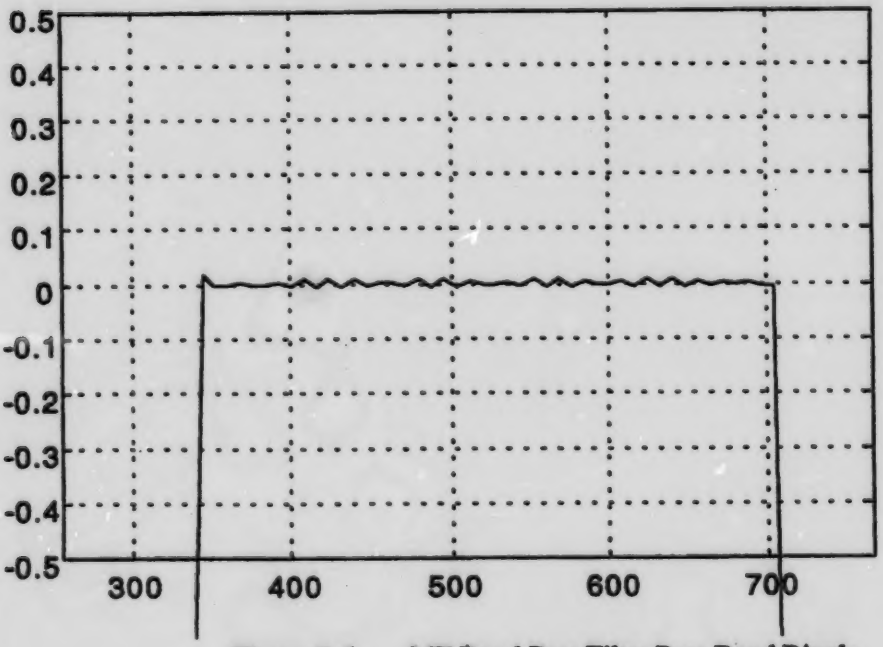


Figure 7-6 MF Band Pass Filter Pass Band Ripple

7.4 HF Low Pass Filter

The HF band is filtered and transformed into a 1024 Hz time series. The transition bands and pass band are constrained to a 1024 Hz band. The MF pass band is 696 to 1404 Hz.

The MATLAB script used to design the HF low pass filter is:

MATLAB script:

```
n=958;
m=[ 0 0 1 1 0 0 ];
f = [ 0 660/4096 696/4096 1404/4096 1440/4096 1];
b = remez(n,f,m);

#save to file
fid = fopen( 'firHF.txt', 'w' );
fprintf( fid, '   %16.8e,\n',b);
fclose(fid);

# plot frequency response
[H,w]=freqz(b);
plot( 4096*w/pi,20*log(abs(H)))
grid on

# plot pass band ripple
axis( [ 512 1535 -0.5 0.5 ] )
```

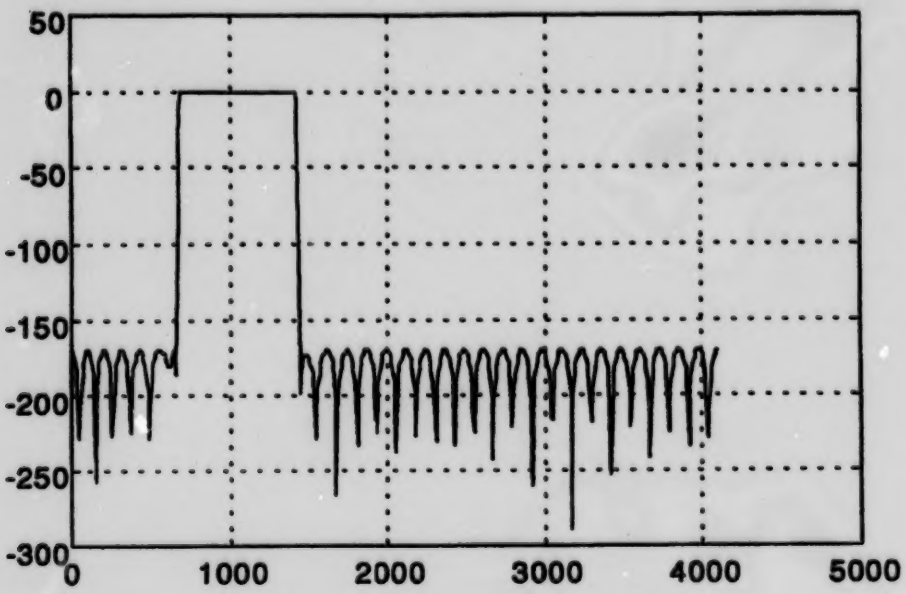


Figure 7-7 HF Band Pass Filter Frequency Response

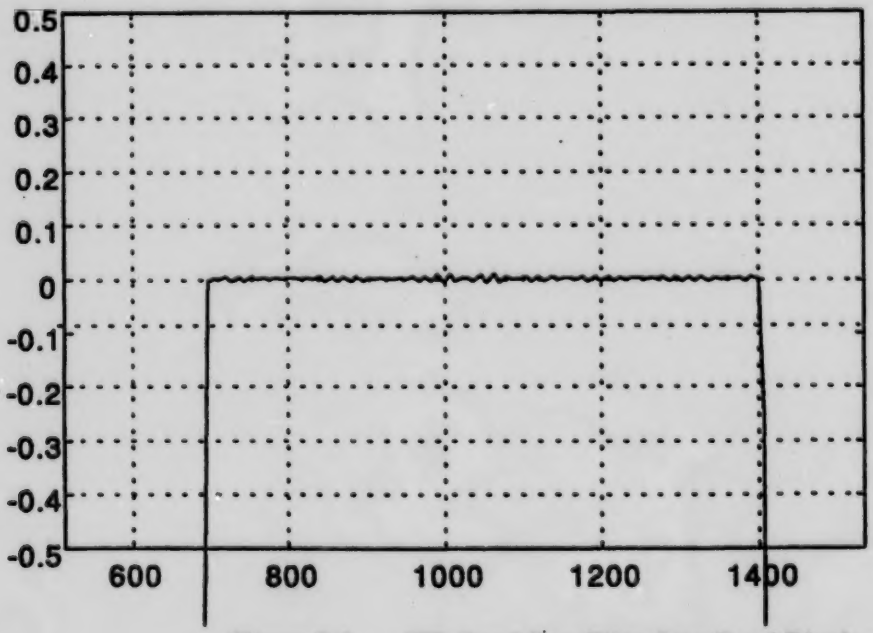


Figure 7-8 HF Band Pass Filter Pass Band Ripple

8. Match Filter Load Analysis

This section presents the results of a computational load analysis for an implementation of the full kernel and sub-kernel match filter processing on the NGSP. Refer to section 13.2.3 and 13.2.4 of this document for the processing requirements for the full kernel match filter and sub-kernel match filter processing. These estimates assume full utilization of the 40 MHz vector pipeline of an AU. The cycle count for the actual implementation of each function is used. Instruction and pipeline startup cycles are not factored into the estimates.

The following table presents the results of the match filter loading analysis:

function	beams	size	cycles	Cycles	Time(ms)
fft	56.0	16384.0	7.0	6422528.0	
multiply	56.0	16384.0	1.0	917504.0	
ifft	56.0	16384.0	7.0	6422528.0	
magsq	56.0	8192.0	1.0	458752.0	
swap	28.0	8192.0	1.0	229376.0	
normalize	28.0	8192.0	21.0	4816896.0	
resolution reduce	28.0	7936.0	5.0	1111040.0	
quantize	28.0	16128.0	3.0	1354752.0	
clip	28.0	16128.0	2.0	903168.0	
total				22636544.0	565.9

The estimated processing time from the table above for each match filter executing on an AU of the NGSP is 570 ms. The processing period for the match filter processing is 16 seconds. Therefore, the maximum number of match filters that can execute on an AU of the NGSP is 28. However, the real processing performance of the NGSP is typically about 85 percent of the theoretical. This would indicate that a single NGSP AU could perform 24 match filters as specified in section 13.2.4.

9. Match Filter Kernel Generation Investigation

This section describes the results of the investigation into different approaches for the generation of match filter kernels. The following four approaches to generating match filter kernels were analyzed and are discussed in this section:

- transmitter supplied
- run time generated
- compile time generated
- off line generated

Match filter processing can potentially use a large number of kernels concurrently during processing to account for doppler. These kernels are only a subset of a larger number of kernels that potentially would be required to support the different transmitted waveforms during operations. Assuming a minimal of 20 full kernels and 500 sub-kernels of 16k samples, the memory requirements to support off-line and compile generation of the match filter kernels would be greater than 60 Mbytes. This would represent a significant

amount of memory resources for a signal processor. Consequently these approaches are not practical.

The approach of using a digitized time series sample of the transmitted wavetrain from the transmitter prior to transmission would add considerable complication to the replica generation software for any transmitted wavetrain comprised of more than a single FM waveform. Typically, wavetrains comprise of a combination multiple FM waveforms and/or multiple CW waveforms which may overlap. Extracting individual replicas from the time series would be possible as long as none of the replicas overlapped. Another complication that would typically arise would the sampling rate differences between the transmitter and receiver. Typically, transmitter sampling frequencies are multiples of the receiver sampling frequencies and rarely are they integer multiples. As a result, the transmitted replica would have to transformed to the receiver sampling frequency. Further complication arises when doppler shifted replicas have to be generated from the transmitted replica. This approach should only be considered if the transmitted wavetrain is single FM waveform. In this case, nothing has to be known about the waveform in order to generate a replica. In all other cases, the composition of the wavetrain and the duration of the waveforms have to be known before extracting the replicas from the transmitted wavetrain.

The approach of generating match filter kernels at run time is the most flexible and general approach. The only limitations are that the wavetrain composition and the waveform descriptions need to be known before a transmission. This is easily achieved by parameterizing the wavetrain and waveform definitions and implementing parameteric kernel generation software. Typical parameters that would define a match filter kernel would be type of FM, start frequency, end frequency, duration, doppler shift, and type of weighting.

10. Time Tagging Investigation

This section describes the results of the investigation into time tagging acoustic data and non-acoustic data in ETASS (IV) NGSP. ETASS IV provided relative time tagging between received acoustic data to an accuracy of 2 seconds and absolute time tagging of received acoustic data to an accuracy of five minutes. Active sonar systems need to measure relative time differences between transmitted and received signals to an accuracy of 1 ms and absolute time measurements to a similar accuracy. ETASS IV made use of onboard processor clocks to maintain time. ETASS IV did not consider operating system and processing latencies when making time measurements and time tagging data. Operating system latencies are typically in the order of tens of milliseconds. Processing latencies can be as much as 30 seconds. Consequently, in order to achieve the required time accuracy international time standards will have to be referenced and system latencies will have to be minimized. The only practical approach to obtain an accurate absolute time measurement is through a GPS receiver. These are readily available from various COTS venders and support various high level and low interface configurations. There are two basic approaches to time tagging the received data with the time received from a GPS receiver. The first approach is a software approach and the second is a hardware/firmware approach. The software approach would receive the GPS timing information across a standard serial interface or bus interface from a GPS receiver and tag the data as it is received. Scheduling and driver latencies could potentially introduce delays of up to ten milliseconds or more in tagging the time to the data. The hardware approach would require custom hardware/firmware to be developed to support merging the time tag with the received data. This approach could easily tag each frame of received data with a GPS time value within the required 1 ms accuracy.

11. Event Synchronization

The signal processing function requires certain information in order to perform the correct beamforming FM processing and CW processing on the acoustic data received from the receiver. This information includes, but is not limited to, the following:

- Environmental data
  - magnetic declination
  - speed of sound
- Receiver telemetry
  - course and speed
  - latitude and longitude
- Transmitter telemetry
  - course and speed
  - latitude and longitude
- Transmission Parameters
  - transmission time
  - transmission format
- Processing Parameters
  - processing range
  - processing thresholds

In the case of monostatic operations, all this information is available local from a system component. In the case of bistatic operations, the transmitter telemetry and transmission schedule must be obtained through some form of communication link from the transmitting platform. In some cases, the transmission schedule may established in advance to cover a period of hours. But typically, the transmission schedule is flexible and may change on the fly before each transmission and rarely are successive transmissions identical with a constant transmission rate. In order to be as flexible as possible, the signal processing function should be sent a transmission notification prior to a transmission with enough information to perform the required processing, to complete the required processing before another transmission, and early enough to setup the required processing.

12. DASM Array Beamforming

This section describes the results of the implementation and integration of the DASM beamforming functionality into ETASS IV (NGSP). The HF aperture DASM directional array provides additional directive gain, as well as, the capability of resolving left and right ambiguity that is inherent with conventional linear arrays comprised of the same number of elements.

The DASM beamforming functionality was implemented using the NGSP IPE. A dipole beamform class was developed which transformed the 32 omni and sine channel spectra into 56 sets of 32 directional channel spectra by weighting and then summing together the associated omni and sine channel spectra. Each set of directional channel spectra was transformed into a directional beam spectra using a linear beamformer. The look directions of directional beams were set to be equally spaced in cosine space through 360 degrees. The directional channels were formed using shading coefficients which directed the null in the dipole cardiod in the ambiguous direction of the directional beam. Refer to section 13.2.1.2 of this document for the detailed specification of the directional sensor signal processing.

13. Active Towed Array Sonar Application

This section describes the active towed array sonar application (ATASA) developed to perform monostatic and bistatic signal processing and display processing on low frequency active sonar data. Section 13.1 presents an system overview of the hardware components that supported the ATASA development and describes the software components of ATASA. Section 13.2 presents the ATASA signal processing characteristics. Section 13.3 presents the ATASA display processing characteristics

13.1 ATASA System Overview

Figure 13-1 identifies the hardware components that support ATASA. Figure 13-2 identifies the software components of ATASA. The ATASA software was developed using commercial software environments in order to be as independent of a particular hardware platform as possible. The display processing software used X windows to ensure maximum portability across various platforms. The signal processing software used the NGSP Integrated Programming Environment(IPE). In addition to the NGSP, the IPE is supported on several commercial UNIX workstations. The IPE allowed for the signal processing software to be developed and run on commercial workstation and then ported to the NGSP. However, for software to run efficiently on the NGSP, the software was developed with consideration for the NGSP architecture.

The ATASA software supports the input of array time series from an array in real time, as well as, input of beam time series data in a standard file format from either a disk file or a tape file. The signal processing software supports frequency domain beamforming for directional and non-directional linear arrays, bandpass filtering and heterodyning, frequency modulation processing, continuous wave processing, narrowband processing, broadband processing and audio processing.
The display processing software supports the concurrent display of the various processed acoustic data generated by the signal processing software. The display processing software includes a set of data servers which manage the storage and distribution of a particular type of data. Any application can request or subscribe for this data through using a set of server routines. This approach allows for other applications to easily interface to the ATASA data servers to obtain or even provide data.

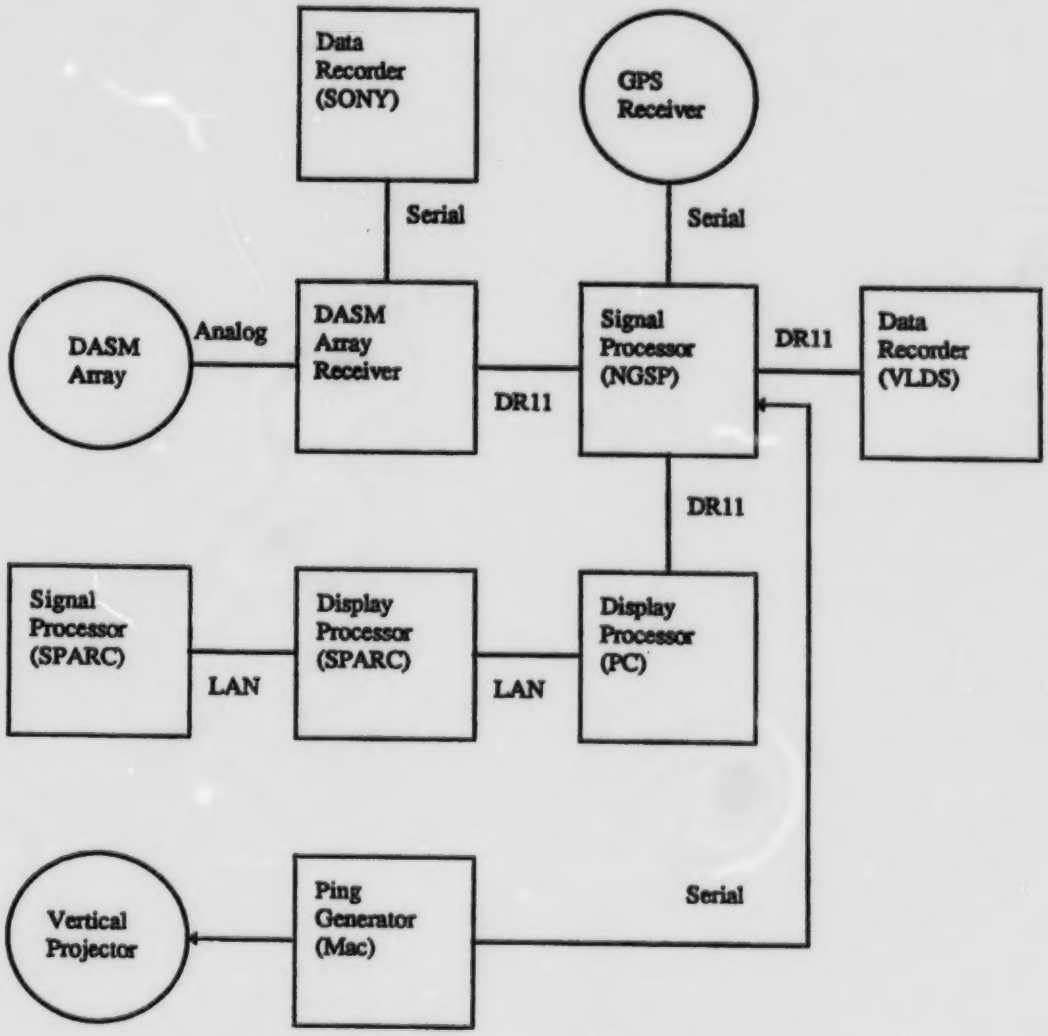


Figure 13-1 ATASA Functional Block Diagram

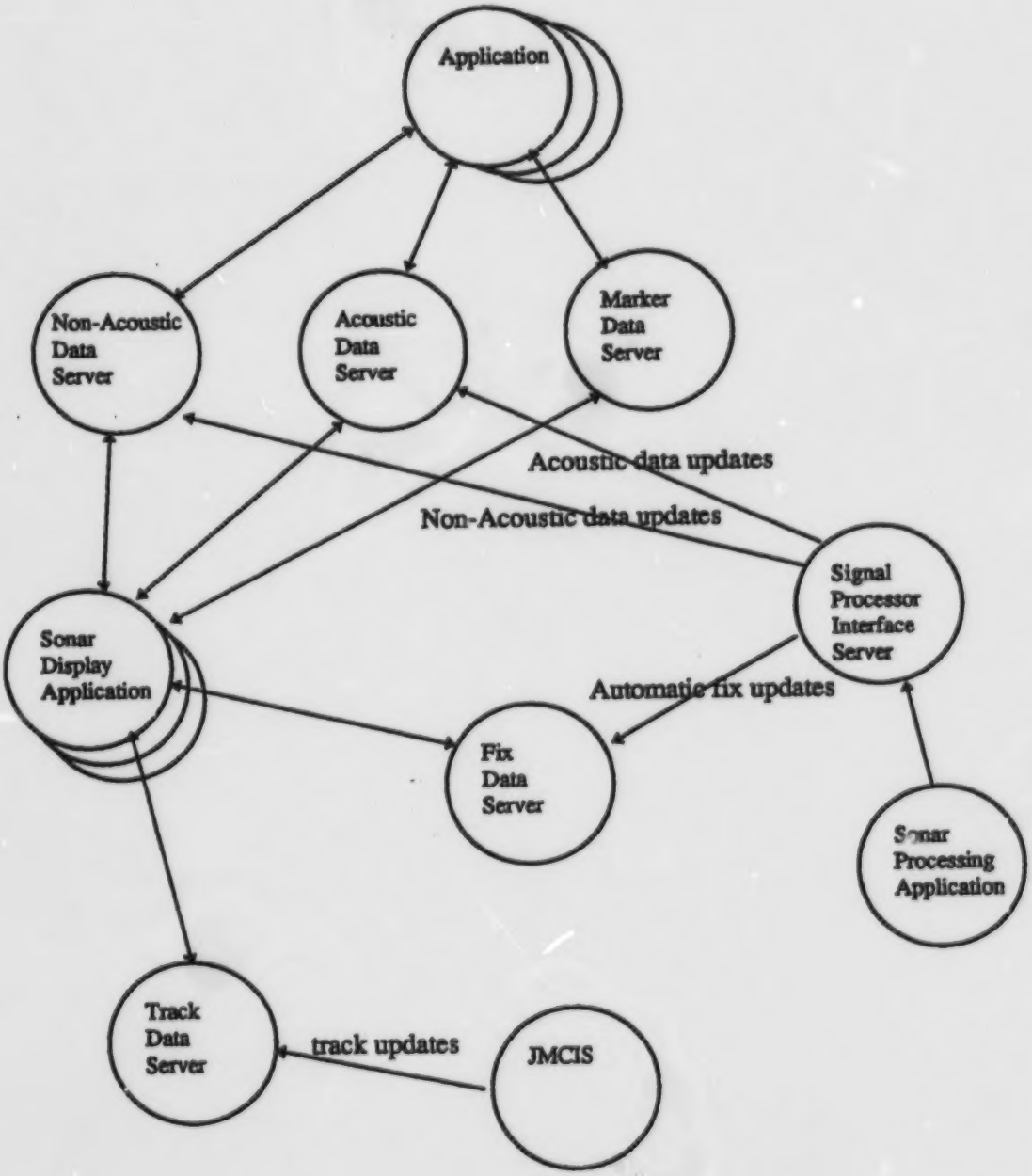


Figure 13-2 ATASS Software Components

13.1.1 ATASA Data Server Characteristics

The following sections describe the data characteristics and the application program interface(API) characteristics of the following ATASA data servers:

- acoustic data server
- non-acoustic data server
- marker data server
- fix data server
- track data server

13.1.1.1 Acoustic Data Server Characteristics

The acoustic data server provides the acoustic data management function for ATASA. Acoustic data generated by ATASA components or other applications is sent to the acoustic data server for storage. ATASA components or other applications retrieve the acoustic data from the acoustic data server either by request or automatically by subscription. The acoustic data server supports a set of API routines that ATASA components and other applications use to communicate with the acoustic data server.

13.1.1.1.1 Acoustic Data Characteristics

The acoustic data server supports the storage and retrieval of arbitrary data sets of various formatted data of up to three dimensions. The acoustic data is specified through a configuration file. The acoustic data is comprised of the following items.

- data descriptor
  - acoustic data identifier
  - acoustic data format
    - 4-bit packed nibble integer
    - 8-bit integer
    - 16-bit integer
    - 32-bit floating point
    - 64-bit complex floating point
  - x, y and z size
  - x, y and z resolution
- scan descriptor
  - status
    - data timeout
    - vaild data
  - system data tag
- acoustic data tag
- acousic data

13.1.1.1.2 Acoustic Data Server Interface Characteristics

- acoustic data subscribe
  - acoustic data identifier
  - subscription identifier
    - x, y and z coordinates
    - x, y and z step size
    - x, y and z size

- acoustic data unsubscribe
  - subscription identifier
- acoustic data configuration
  - acoustic data identifiers
- acoustic data description
  - acoustic data identifier
  - x, y and z resolutions
  - x, y and z size
  - format
- acoustic data request
  - inputs
    - acoustic data identifier
    - request identifier
    - x, y and z coordinates
    - x, y and z step size
    - x, y and z size
  - outputs
    - request identifier
    - acoustic data
- acoustic data update
  - subscription identifier
  - acoustic data identifier
  - system data tag
  - acoustic data

13.1.1.2 Fix Data Server Characteristics

13.1.1.2.1 Fix Data Characteristics

- latitude
- longitude
- time

13.1.1.2.2 Fix Data Interface Characteristics

- fix data subscribe
- fix data unsubscribe
- create fix
- delete fix
- update fix
- fix data request
- fix data update

13.1.1.3 Non-Acoustic Data Server Characteristics

13.1.1.3.1 Non-Acoustic Data Characteristics

The non-acoustic data comprises of the following attributes:

- Time
  - GPS time
  - Playback Time
- Ship position
  - ship position select
  - manual ship latitude
  - manual ship longitude
  - GPS ship latitude
  - GPS ship longitude
- Source position
  - projector position select
  - manual projector latitude
  - manual projector longitude
  - GPS projector latitude
  - GPS projector longitude
- Ship heading
  - ship heading select
  - manual ship heading
  - GPS ship heading
- Ship speed
  - ship speed select
  - manual ship speed
  - GPS ship speed
- Salinity
- Speed of sound
  - speed of sound select
  - manual speed of sound
  - computed speed of sound
- Magnetic declination
  - magnetic declination select
  - manual magnetic declination
  - GPS magnetic declination

The AN/SQR-19 array non-acoustic data comprises of the following attributes:

- Heading
  - heading select
  - manual heading
  - array heading
- Depth
- Cable scope
- Temperature
- Synchronization status
- Shunt current
- Voltage
- Gain

- Mode

The DASM array non-acoustic data comprises of the following attributes:

- Heading
  - heading select
  - manual heading
  - forward array heading
  - after array heading
  - average array heading
- Depth
  - depth select
  - forward depth
  - after depth
  - average depth
- Cable scope
- Temperature
- Gain

13.1.1.3.2 Non-Acoustic Data Server Interface Characteristics

- non-acoustic data subscribe
- non-acoustic data unsubscribe
- non-acoustic data request
- non-acoustic data update

13.1.1.4 Marker Data Server Characteristics

13.1.1.4.1 Marker Data Characteristics

- marker identifier
- acoustic data identifier
- bearing
- frequency
- time
- amplitude
- marker status
- description
- signal follower control
- signal follower control

13.1.1.4.2 Marker Data Server Interface Characteristics

- marker data subscribe
- marker data unsubscribe
- create marker

    - bearing
    - frequency
    - time
    - acoustic data identifier
- delete marker
    - marker identifier
- move marker
    - marker identifier
    - bearing
    - frequency
    - time
- edit marker
    - marker identifier
    - signal follower control
    - description
- marker data request
    - marker identifier
- marker data update
    - marker identifier
    - bearing
    - frequency
    - time
    - amplitude
    - signal follower status
    - description

13.1.1.5 Track Data Server Characteristics

13.1.1.5.1 Track Data Characteristics

- track identifier
- latitude
- longitude
- course
- speed

13.1.1.5.2 Track Data Server Interface Characteristics

- track data subscribe
- track data unsubscribe
- create track
- delete track
- update track
- track data request
- track data update

13.2 ATASA Signal Processing Characteristics

The ATASS signal processing characteristics (based on 4096 Hz sampling frequency) are summarized as follows:

- directional beamformer
  - 1 s time window overlapped by 25%
  - 950 - 1450 Hz band
  - 32 equally spaced dipole sensors
  - 56 beams equally spaced in cosine space over 360 degrees
- broadband
  - 950 - 1450 Hz band
  - 1.5, 3 and 9 s integration periods
- passive
  - 950 - 1450 Hz band
  - 16 s time window overlapped by 50%
  - coarser resolutions generated by oring
- audio
  - 950 - 1450 Hz band
  - 2 channels
  - beam or omni sensor
- Full Kernel FM
  - 950 - 1450 Hz Band
  - kernel length of up to 16 s
  - coarser resolutions generated by oring
  - m of n detector
- Sub-Kernel FM
  - 950 - 1450 Hz Band
  - 32 concurrent sub-kernels
  - kernel length of up to 16 s
  - coarser resolutions generated by oring
- CW
  - 950 - 1450 Hz band
  - 4 s time window overlapped by 75%
  - m of n detector
  - doppler conversion
- Transmission Loss
- Explosive Echo Ranging
  - 950-1450 Hz band
  - 32 ms time window overlapped by 50%
  - 16 point FFT
  - maximum energy over band of interest

13.3 ATASA Signal Processing Specification

This section presents the ATASA signal processing specification. The ATASA signal processing has been decomposed into the following functional components:

- frame analysis
- aperture analysis
- spatial analysis
- continuous wave analysis
- frequency modulation analysis
- audio analysis
- broadband analysis
- narrowband analysis
- transmission loss analysis
- explosive echo ranging

13.3.1 Frame Analysis Specification

- convert from integer to floating point
- extract array non-acoustic data
- concatenate channel time series

13.3.2 Aperture Analysis Specification

- 0.75 second rate
- 4096 point FFT with 25% overlap
- omni channel spectral data from 1024 to 1536 Hz at 1 Hz resolution
- sine channel spectral data from 1024 to 1536 Hz at 1 Hz resolution

13.3.3 Spatial Analysis Specification

- 0.75 second rate
- Generate 56 directional beams spectra equally spaced in cosine space
- cardiod beamforming using Stockhausen shading
    - 32 omni and sine channels from 1024 -1536 Hz at 0.5 m spacing
    - Variable speed of sound 1450 to 1550 m/s

13.3.4 Band Analysis Specification

- 0.75 second rate
- bandpass filter beam spectra
    - 892 point low pass FIR
    - 512 Hz sample frequency
    - heterodyne frequency multiple of 1280 Hz
- decimated beam time series at 512 Hz
    - 512 point IFFT
    - discard first 128 points
        filter length of 64 points
        array length of 64 points

- keep next 384 points
- concatenate time series

13.3.5 Frequency Modulation Analysis Specification

13.3.5.1 Match Filter Replica Specification

- 16 second duration
- 512 Hz sample frequency
- 8192 point time series padded with 8192 zeros at end
- 16384 point FFT
- complex conjugate

13.3.5.2 Match Filter Quadrature Replica Specification

- 16 second duration
- 512 Hz sample frequency
- 8192 point time series padded with 4096 zeros at beginning and 4096 zero at end
- 16384 point Hilbert transform
- complex conjugate

13.3.5.3 Frequency Modulation Match Filter Analysis

- 1.953 ms resolution
- 16 second rate
- 16384 point time series with 8192 point overlap.
- 16384 point FFT.
- multiply with replica spectra.

- 16384 point IFFT.
- discard first (4096-32) points
- keep next (8192+64) points
- square of time series

13.3.5.4 Frequency Modulation Quadrature Match Filter Analysis

- 1.953 ms resolution
- 16 second rate
- 16384 point time series with 8192 point overlap.
- 16384 point FFT.
- multiply with quadrature replica spectra.
- 16384 point IFFT.
- discard first (4096-32) points
- keep next (8192+64) points
- square of time series

13.3.5.5 Frequency Modulation Match Filter Time Series Combination

- add squared time series and square quadrature time series

13.3.5.6 Frequency Modulation Normalization

- two pass split window normalizer
  - 14-5-14 split window
- 8192 points of normalized time series at 1.953 ms resolution

13.3.5.7 Frequency Modulation Time Resolution Reduction

- or adjacent bins together
  - sixth root of sum of the sixth order of the two adjacent bins
- six resolutions
  - 3.906 ms
  - 7.812 ms
  - 15.625 ms
  - 31.25 ms
  - 62.5 ms
  - 125.0 ms

13.3.5.8 Frequency Modulation Quantization

- scaled logarithmic function
- clip between 0 and 7

13.3.6 Segmented Active Analysis Specification

13.3.6.1 Segmented Active Replica Specification

- 4 second duration
- 512 Hz sample frequency
- 2048 point time series padded with 1024 zeros at beginning and 1024 zero at end
- 4096 point FFT
- complex conjugate

13.3.6.2 Segmented Quadrature Replica Specification

- 16 second duration
- 512 Hz sample frequency
- 8192 point time series padded with 4096 zeros at beginning and 4096 zero at end
- 16384 point Hilbert transform
- complex conjugate

13.3.6.3 Segmented Active Match Filter Analysis

- 1.953 ms resolution
- 4 second rate
- 4096 point time series with 2048 point overlap.
- 4096 point FFT.
- multiply with replica spectra.
- 4096 point IFFT.
- discard first (1024-32) points

- keep next (2048+64) points
- square of time series

13.3.6.4 Segmented Quadrature Active Match Filter Analysis

- 1.953 ms resolution
- 4 second rate
- 4096 point time series 2048 point overlap.
- 4096 point FFT.
- multiply with quadrature replica spectra.
- 4096 point IFFT.
- discard first (1024-32) points
- keep next (2048+64) points
- square of time series

13.3.6.5 Segmented Active Time Series Combination

- add squared time series and square quadrature time series

13.3.6.6 Segmented Active Normalization

- two pass split window normalizer
  - 14-5-14 split window
- 2048 points of normalized time series at 1.953 ms resolution

13.3.6.7 Segmented Active Time Resolution Reduction

- or adjacent bins together
  - sixth root of sum of the sixth order of the two adjacent bins
- six resolutions
  - 3.906 ms
  - 7.812 ms
  - 15.625 ms
  - 31.25 ms
  - 62.5 ms
  - 125.0 ms

13.3.6.8 Segmented Active Quantization

- scaled logarithmic function
- clip between 0 and 7

13.3.7 Continuous Wave Analysis Specification

13.3.7.1 Continuous Wave Spectral Analysis

- 0.25 Hz resolution
- 4 second aperture
- 1 second rate
- 2048 point Hamming window
- 2048 point FFT with 512 point overlap

- magnitude of spectral power from 1100.0 to 1400.0 Hz

13.3.7.2 Continuous Wave Normalization

- two pass split window normalizer
  - 5-5-5 split window
- normalized power from 1100.0 to 1400.0 Hz

13.3.7.3 Continuous Resolution Reduction

- or adjacent power bins together
  - sixth root of sum of the sixth order of the two adjacent power bins
- two resolutions
  - 0.25 Hz from 1100.000 to 1400.0 Hz
  - 0.5 Hz from 1100.00 to 1400.0 Hz

13.3.7.4 Continuous Wave Quantization

- scaled logarithmic function
- clip between 0 and 7

13.3.7.5 Continuous Wave Doppler Analysis

13.3.8 Audio Analysis Specification

- 0.75 second rate
- 3 beams
- bandpass filter beam spectra 250 to 1400 Hz
- synthesis negative spectra
- 4096 point IFFT
- 4096 Hz real time series

13.3.9 Broadband Analysis Specification

13.3.9.1 Broadband Power Integration

- 0.75 second rate
- sum beam spectral magnitudes from 1100 to 1400 Hz
- accumulate beam power for 0.75, 1.5, 3.0 and 9.0 seconds

13.3.9.2 Broadband Normalization

- absolute minimum normalizer

13.3.9.3 Broadband Local Maxima

- find beams with power greater than adjacent beam powers

13.3.9.4 Broadband Bearing Interpolation

- parabolic interpolate each local maximum
- mirror bearing about array axis

13.3.9.5 Broadband Bearing Stabilization

- rotate by array heading

13.3.9.6 Broadband Quantization

- scaled logarithmic function
- clip between 0 and 7

13.3.9.7 Broadband Pixelization

- convert to 3 bit pixel
- broaden line width according to pixel value
- pack pixel into lower 3 bits of 4 bit nibble
- pack 4 nibbles to 16 bit word

13.3.10 Narrowband Analysis Specification

13.3.10.1 Narrowband Spectral Analysis

- 0.0625 Hz resolution
- 16 second aperture
- 8 second rate
- 8192 point Hamming window
- 8192 point FFT with 4096 point overlap
- magnitude of spectral power from 1098.0 to 1402.0 Hz

13.3.10.2 Narrowband Normalization

- two pass split window normalizer
  - 14-5-14 split window
- normalized power from 1100.00 to 1400.00 Hz

13.3.10.3 Narrowband Resolution Reduction

- or adjacent power bins together
  - sixth root of sum of the sixth order of the two adjacent power bins
- four resolutions
  - 0.125 Hz from 1100.000 to 1400.000 Hz
  - 0.25 Hz from 1100.00 to 1400.00 Hz
  - 0.5 Hz from 1100.0 to 1400.0 Hz
  - 1 Hz from 1100 to 1400 Hz

13.3.10.4 Narrowband Quantization

- scaled logarithmic function
- clip between 0 and 7

13.3.11 Transmission Loss Analysis Specification

13.3.11.1 Band Selection for Transmission Loss Analysis

- concatenate channel time series
  - two channels
  - 3920.457 Hz sampling frequency
  - convert from 16 bit 2's complement integer to 32 bit IEEE floating point
- band selection
  - 0.75 second rate
  - 4096 point FFT with 25% overlap
  - 512 point band pass filter about 1255.62 Hz
  - 512 point IFFT
  - discard first 128 points
  - keep last 384 bins of complex time series
  - concatenate complex time series

13.3.11.2 Replica Generation for Match Filter Transmission Loss Analysis

- generate N points of replica time series at 3920.457 Hz sampling frequency
- pad time series with 131072-N points of zero
- 4096 point FFT with overlap of 1024 points
- 512 point IFFT about 1255.62 Hz (point 1312)
- discard first 128 points
- keep last 384 points of complex time series
- concatenate replica complex time series
- repeat until replica time series contains 16384 points
- 16384 point FFT
- 16384 point complex conjugate

13.3.11.3 Match Filter Transmission Loss Analysis

- spectral analysis
  - overlap lap by N points corresponding to length of replica time series
  - 16384 point FFT
- match filter analysis
  - 16384 point complex multiply channel spectra with replica
  - 16384 point IFFT
  - discard first N points
  - keep next 16384-N points of complex match filter time series
  - magnitude of match filter time series
  - concatenate match filter time series
- peak detection
- power estimation

13.3.11.4 Continuous Wave Transmission Loss Analysis

- spectral analysis
  - 512 point overlap

- 1024 point hamming window
- 1024 point FFT
- magnitude of complex spectra
- peak detection
- power estimation

13.3.12 Explosive Echo Ranging Analysis Specification

13.3.12.1 Explosive Echo Ranging Time Series Analysis

- 0.75 second rate
- bandpass filter beam spectra
  - 492 point low pass FIR
  - 4096 Hz sample frequency
  - 200 Hz pass band
  - 20 Hz transition band
  - heterodyne frequency multiple of 16 Hz
- decimated beam time series at 512 Hz
  - 512 point IFFT
  - discard first 122 points
    - filter length of 62 points
    - array length of 60 points
  - keep next 384 points
  - concatenate time series

13.3.12.2 Explosive Echo Ranging Spectral Analysis

- 64 Hz resolution
- 15.6 ms time window
- 128 Hz rate
- 64 point FFT with 32 point overlap
- magnitude of spectral power
- sum spectral power over band of interest
- integrate successive powers

13.3.12.3 Explosive Echo Ranging Time Resolution Reduction

- reduce time resolution by oring
- three time resolutions

13.4 ATASA Signal Processing Design

This section presents the objected oriented design for the ATASA signal processing software. The signal processing design adds to the design for the ETASS IV (NGSP) signal processing presented in section 3.3 of this document. Figure 13-3 identifies the ATASA signal processing software classes and associated operations. Figure 13-4 identifies the ATASA signal processing software object interaction.

The frequency modulation analysis supports the match filter processing of the input time series. The processing performed by this class is defined by the following attributes:

- input time series
- replica spectra
- overlap points
- pre-normalization compression factor
- post normalization compression factor
- quantization scale and offset

The continuous wave analysis class supports the spectral analysis of the input time series. The processing performed by this class is defined by the following attributes:

- input time series
- window time series
- overlap points
- spectra keep and discard points
- integration factor
- quantization scale and offset

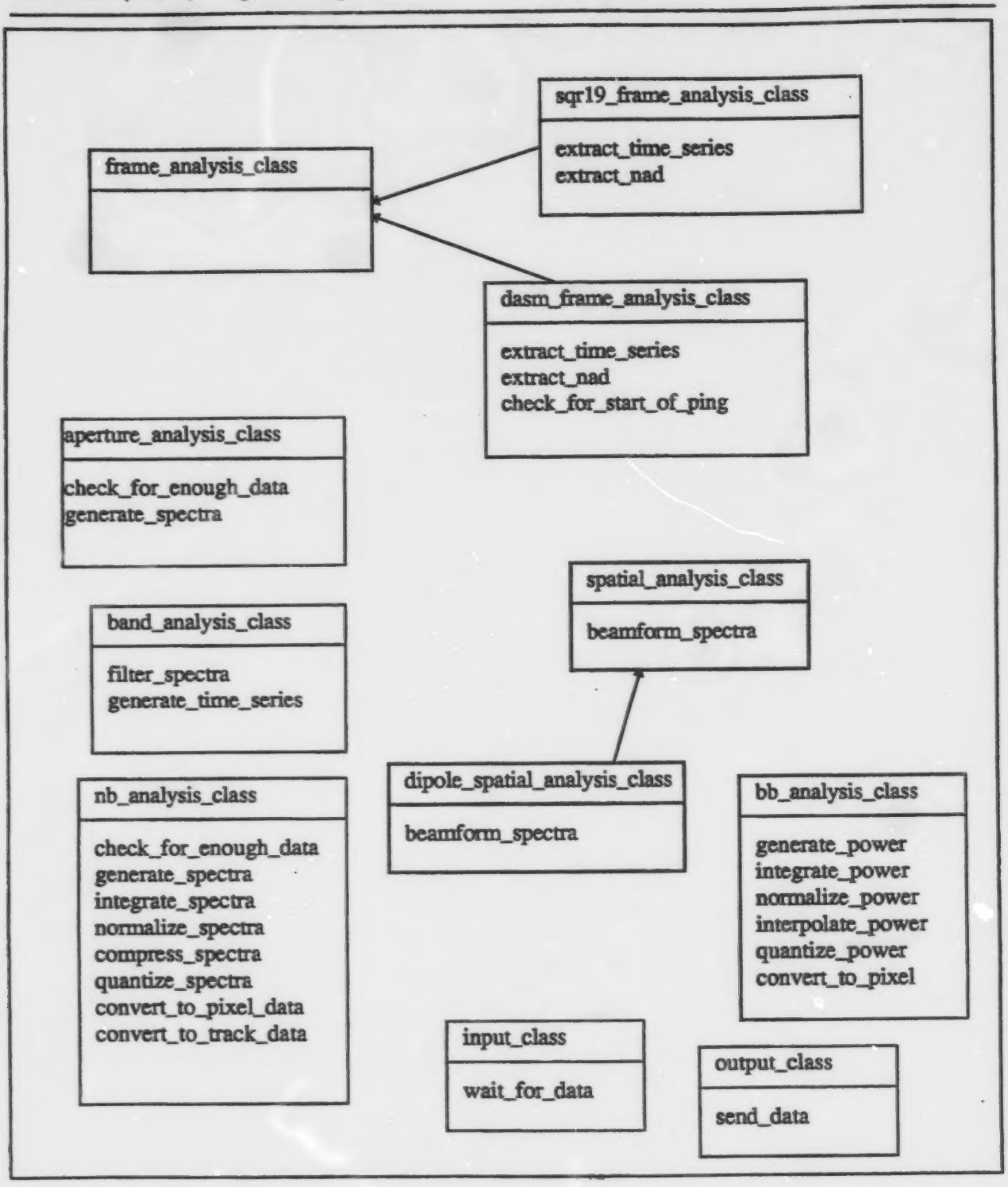
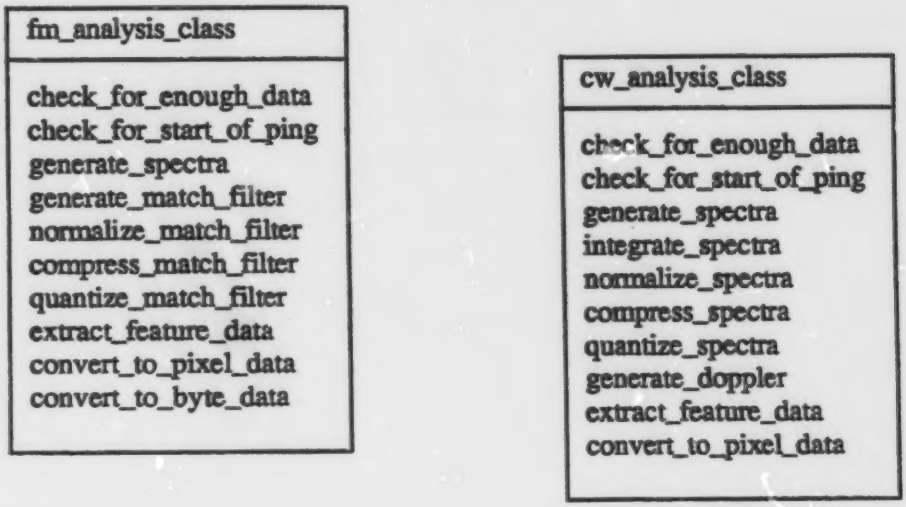
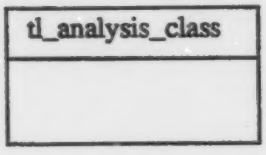
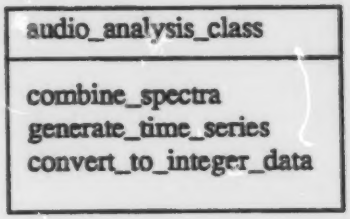


Figure 13-3 ATASA Signal Processing Software Class Operations







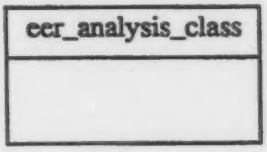


Figure 13-3 ATASA Signal Processing Software Class Operations (con't)

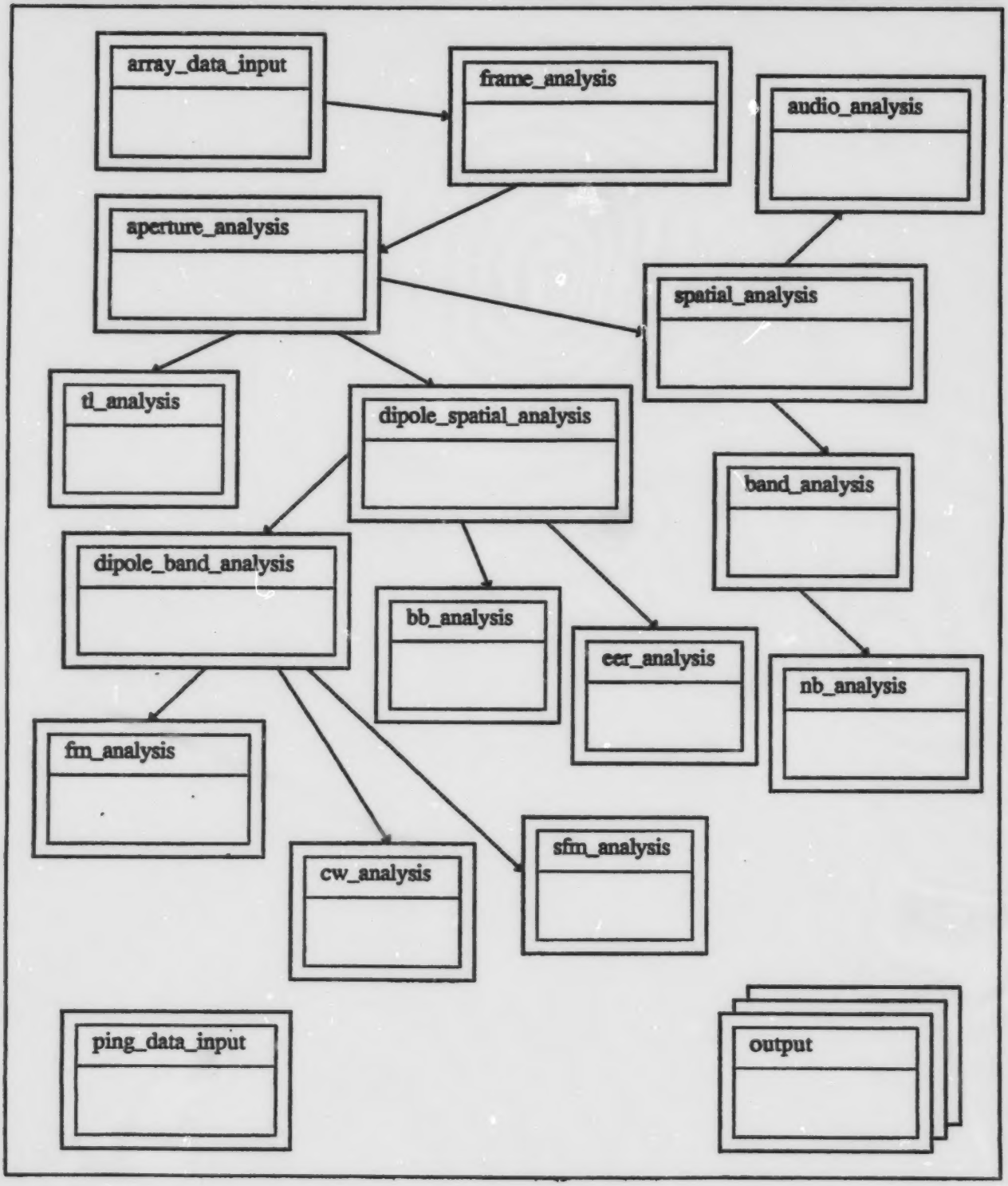


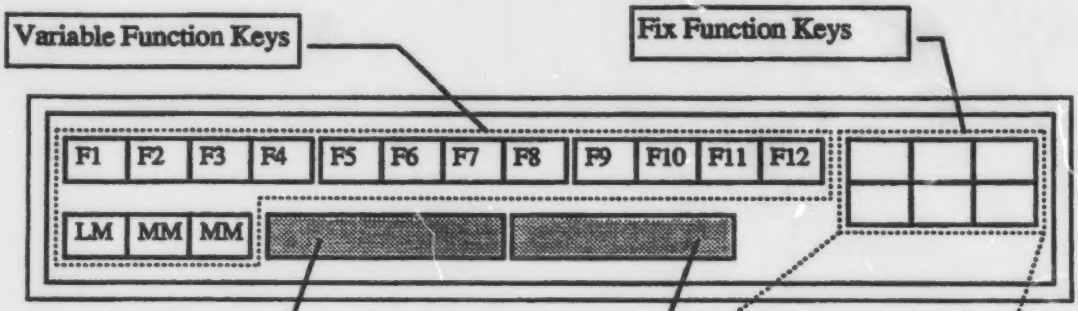
Figure 13-4 ATASA Signal Processing Software Object Interaction

13.5 ATASA Display Processing Characteristics

The ATASA display processing characteristics are summarized as follows:

- Tactical plot
  - own ship and track
  - other platforms and tracks
  - fixes
  - bearing line
  - ellipse/circle localization
  - bathymetry
  - coastline
  - overlays
- Passive search summary
- Passive multi-beam
- CW search summary
- CW multi-beam
- CW Doppler search summary
- CW Doppler multi-beam
- Full kernel FM search summary
- Full kernel FM multi-beam
- Sub-kernel FM search summary
- Sub-kernel FM multi-beam
- Broadband
- Cursors
  - line cursor
  - comb cursor
  - harmonic cursor
  - time delay cursor

Figure 13-5 presents the function key format. This format identifies the fixed function keys and the variable function keys and identifies the current mapping of a application function to a key. The function keys on the the trackball and the keyboard and trackball are the primary operator inputs to ATASA. The variable function keys are context sensitive. This means that each variable key has multiple meanings. At any instant, the function that will be executed when a variable key is pressed depends on where the pointer is positioned and what fix function key is selected. Figure 13-6 presents a the select display function key hierarchy. Figure 13-7 presents the view commands function key hierarchy for the multiple pane format and the tactical plot format.



Insert	Home	PageUp
SELECT DISPLAY	VIEW CMDS	WINDOW CMDS
Delete	End	PageDown
FIX CMDS		HARD COPY

Figure 13-5 Function Key Format

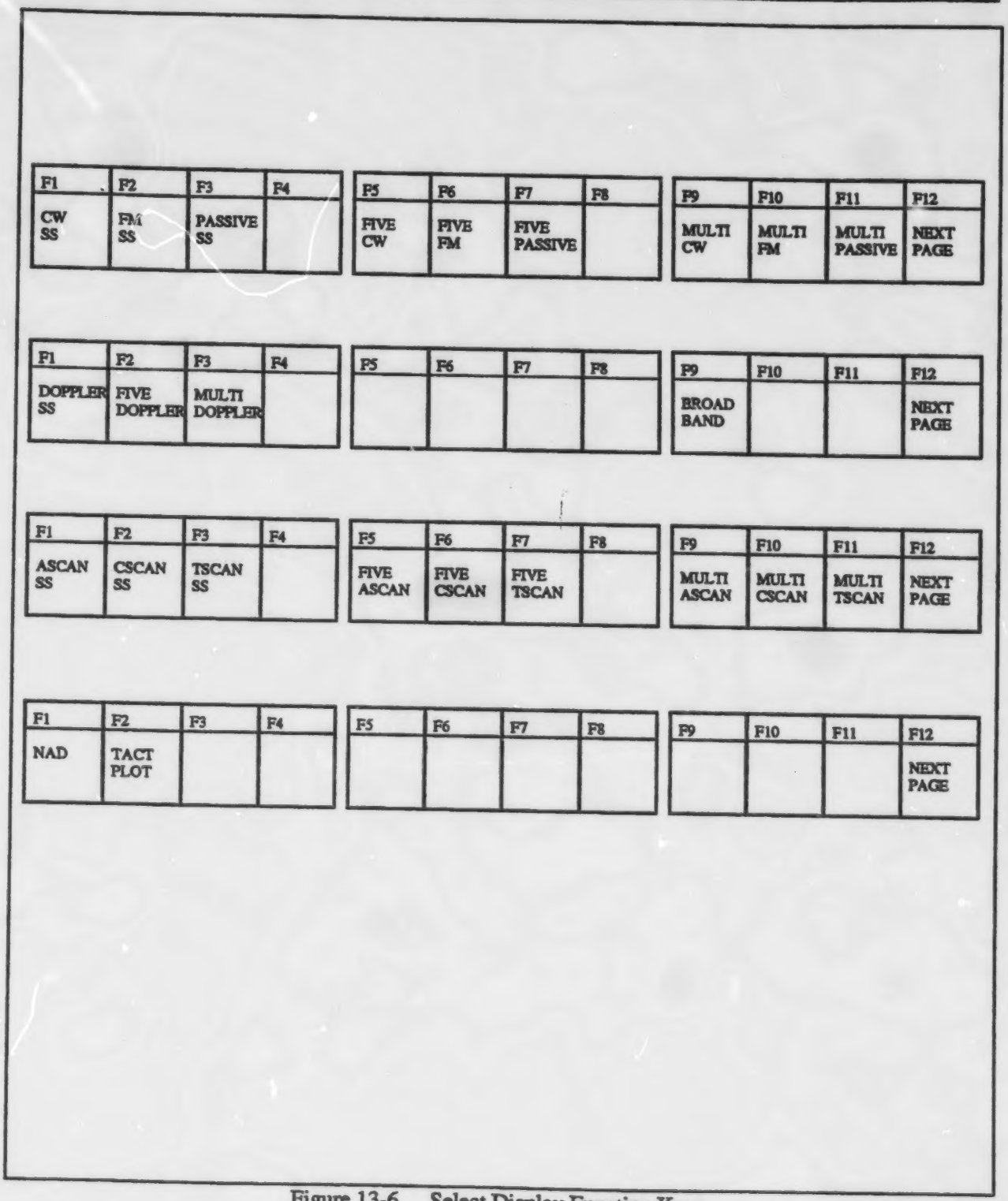


Figure 13-6 Select Display Function Keys

F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12
SHIFT LEFT	SHIFT RIGHT	SCROLL	DEC BY VALUE	DEC BY THREE	DEC BY ONE	INC BY ONE	INC BY THREE	INC BY VALUE	ZOOM IN	ZOOM OUT	NEXT PAGE
SHIFT BACK	SHIFT FWD										NEXT PAGE

Multiple Pane Format View Commands

F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12
ZOOM IN	ZOOM OUT	SHIP CENTER	CURSOR CENTER	PLTFRM LABELS OFF	PLTFRM TRACKS OFF	FIXES OFF	FIX LABELS OFF				NEXT PAGE
BATHY ON	COAST ON	GRID ON									NEXT PAGE

Tactical Plot View Commands

Figure 13-7 View Commands Function Keys

Figure 13-8 presents the layout the an acoustic data pane format. Figure 13-9 presents a multiple pane format where a number of panes are vertically displayed. Figure 13-10 presents a search summary pane format where two vertical columns of panes are displayed. The last two formats are extensions of the first. All these formats support display acoustic data in the following forms:

- bearing versus time
- frequency versus time
- amplitude versus time

These figures present a line cursor which is moved over the displayed acoustic data by rotating the trackball. The cursor data area presents the horizontal and vertical axis coordinates of the cursor. These formats also support the following cursors where appropriate for the displayed acoustic data.

- comb cursor
- harmonic cursor
- horizontal offset cursor
- vertical offset cursor

Figure 13-11 presents the comb cursor. This cursor comprises a long vertical base line and multiple equally spaced vertical lines to the right of the base line. A function key provides the ability to toggle between moving the base line as the trackball is rotated or changing the horizontal spacing between the vertical lines. The cursor data area for the comb cursor displays the base line horizontal coordinate and the horizontal spacing between the vertical lines.

Figure 13-12 presents the harmonic cursor. This cursor comprises a set of equally spaced vertical lines. The horizontal position of each vertical line corresponds to an integer multiple of the horizontal spacing between the vertical lines. The horizontal spacing bewteen the vertical lines is changed by rotating the trackball. The cursor data area for the harmonic cursor displays the horizontal spacing between the vertical lines.

Figure 13-13 presents the horizontal offset cursor. This cursor comprises two vertical lines which are identified as the base line and the offset line. This cursor is used to measure the horizontal offset between two points. A function key provides the ability to toggle between moving the base line as the trackball is rotated or moving the offset line. The cursor data area for this cursor display the horizontal coordinate of the base line and the horizontal difference between the base line and the offset.

Figure 13-14 presents the vertical offset cursor. This cursor comprises two horizontal lines which are identified as the base line and the offset line. This cursor is used to measure the vertical offset between two points. A function key provides the ability to toggle between moving the base line as the trackball is rotated or moving the offset line. The cursor data area for this cursor display the base line vertical coordinate of the base and the vertical difference between the base line and the offset.

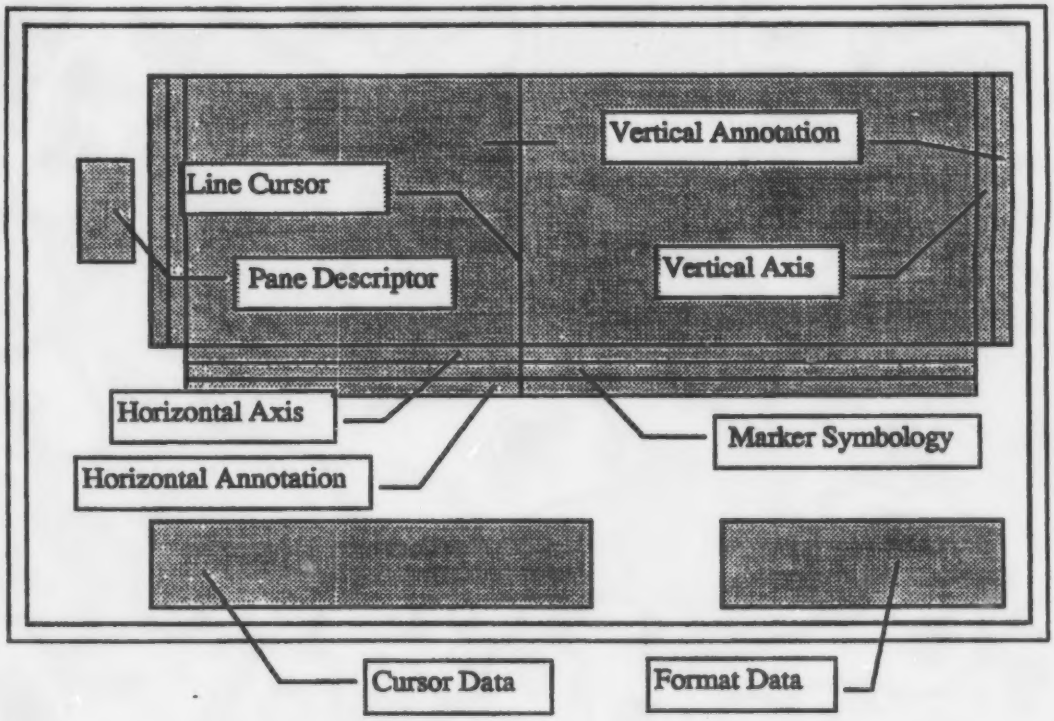


Figure 13-8 Pane Format

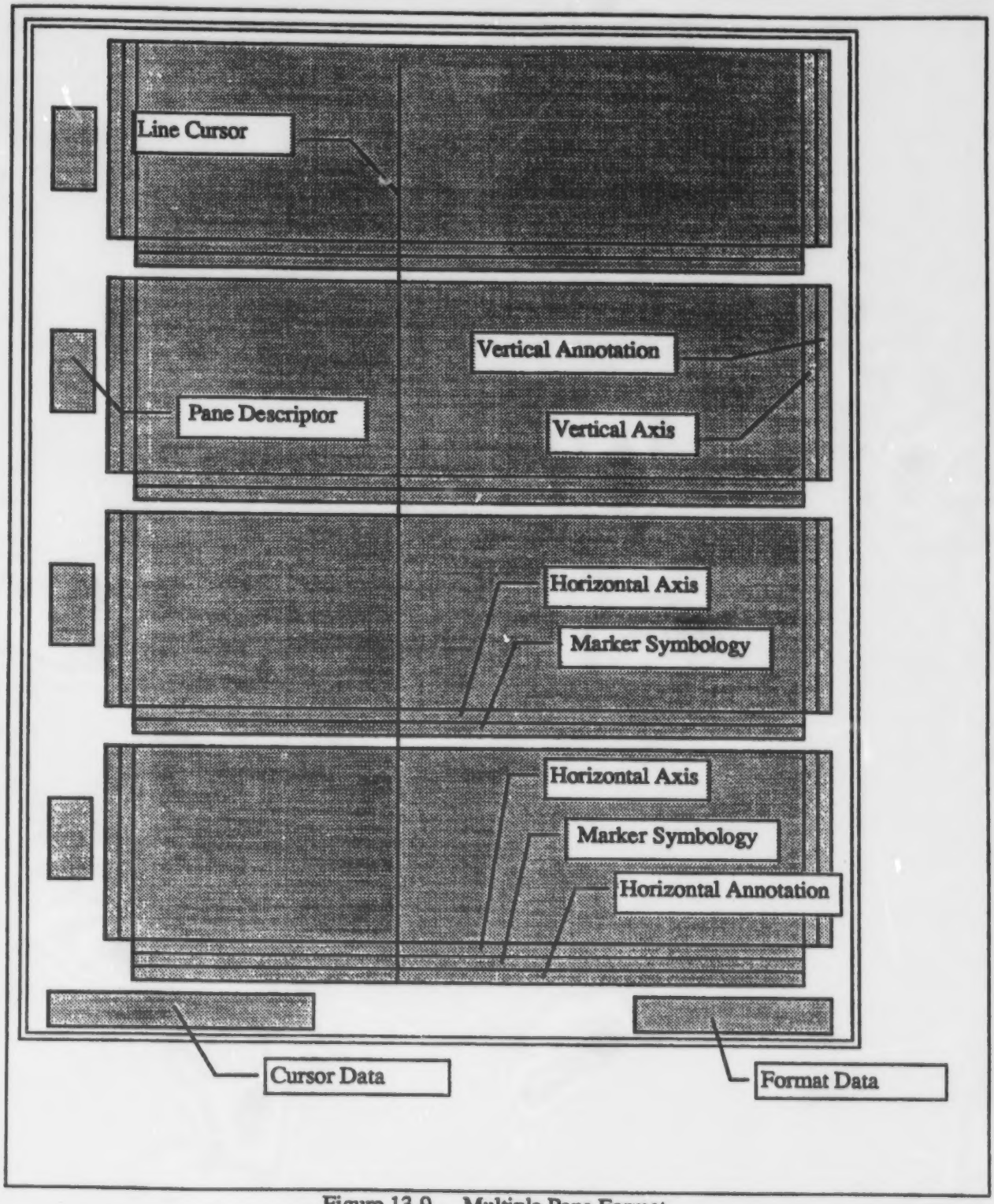


Figure 13-9 Multiple Pane Format

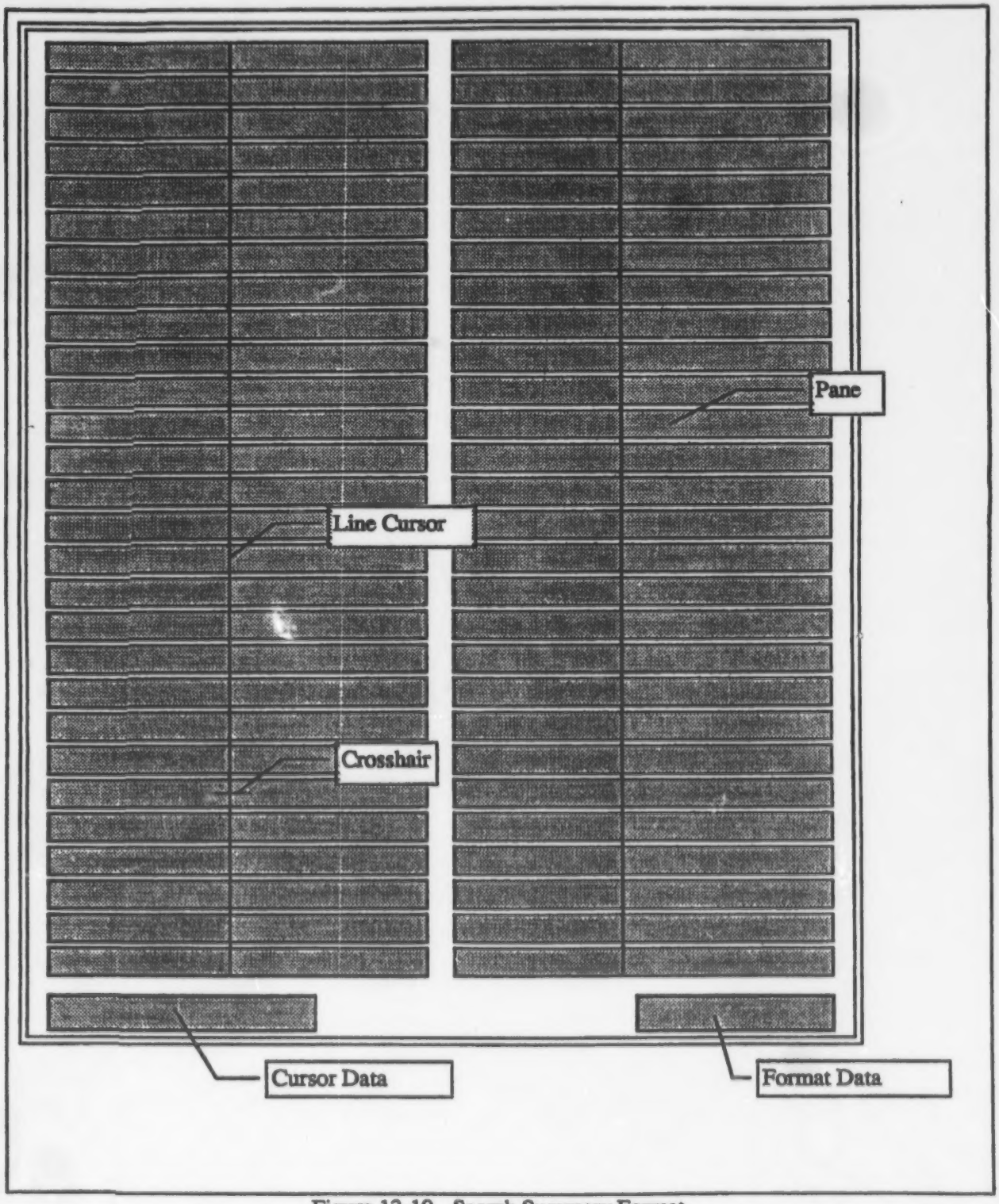


Figure 13-10 Search Summary Format

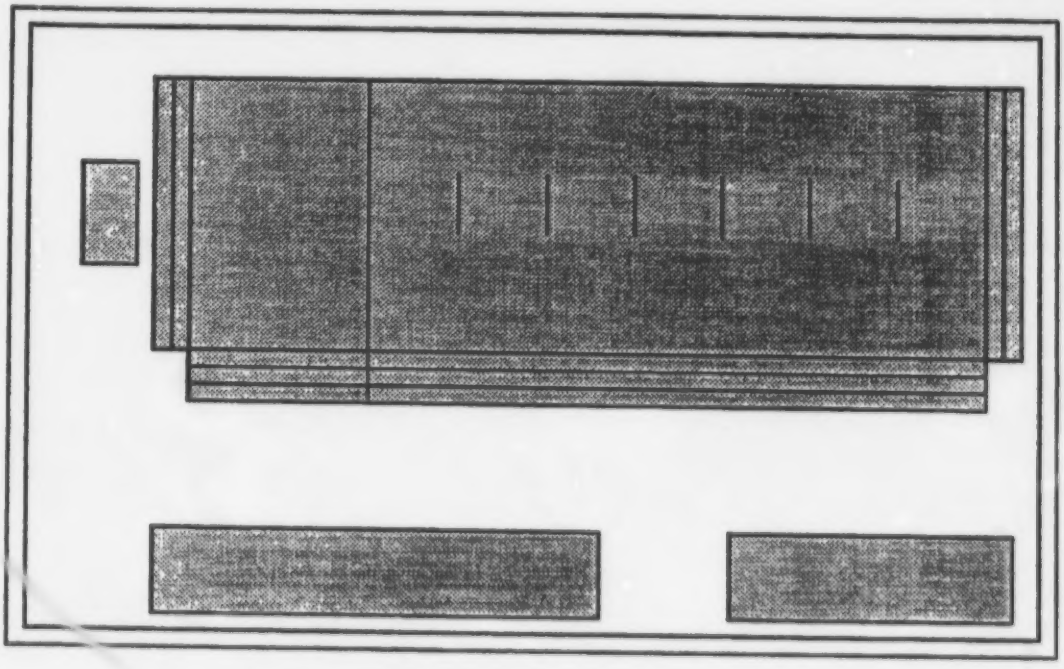


Figure 13-11 Comb Cursor

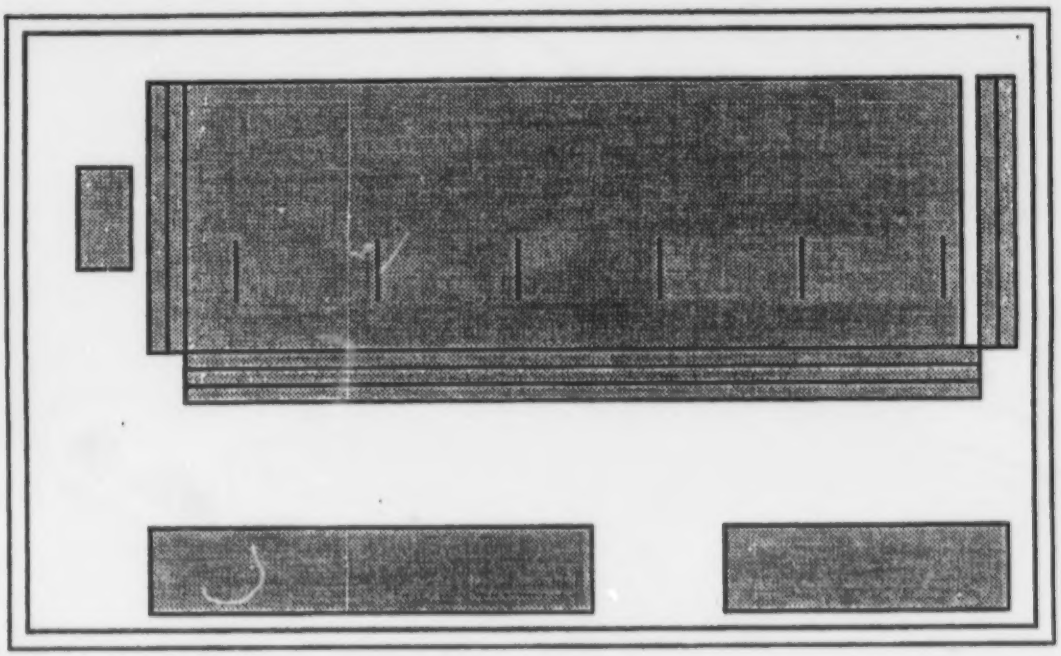


Figure 13-12 Harmonic Cursor

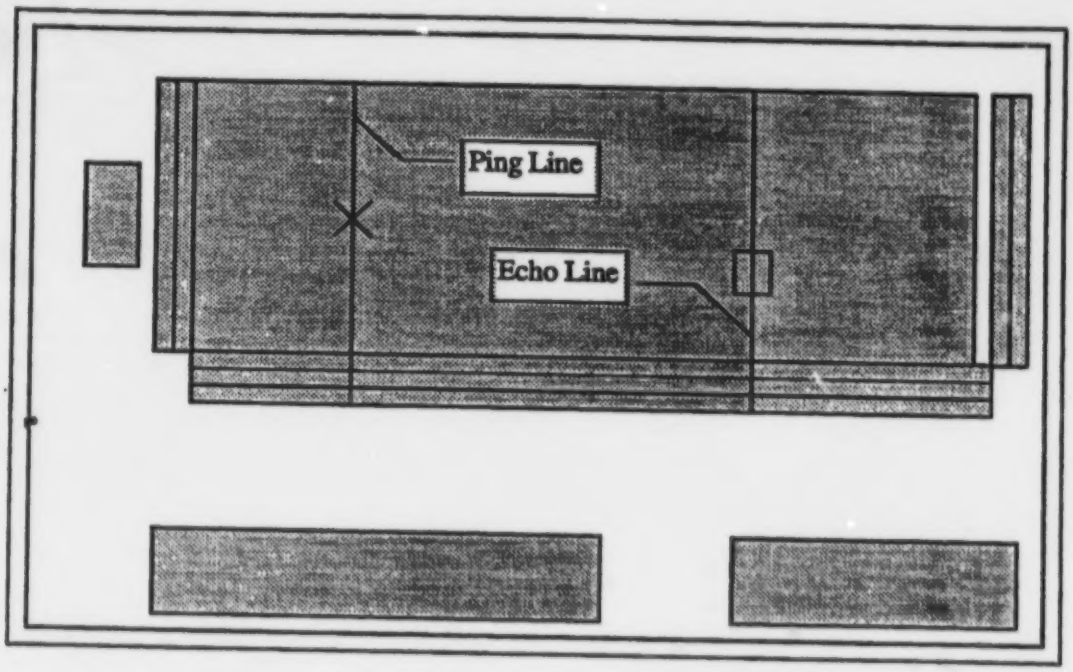


Figure 13-13 Horizontal Range Cursor

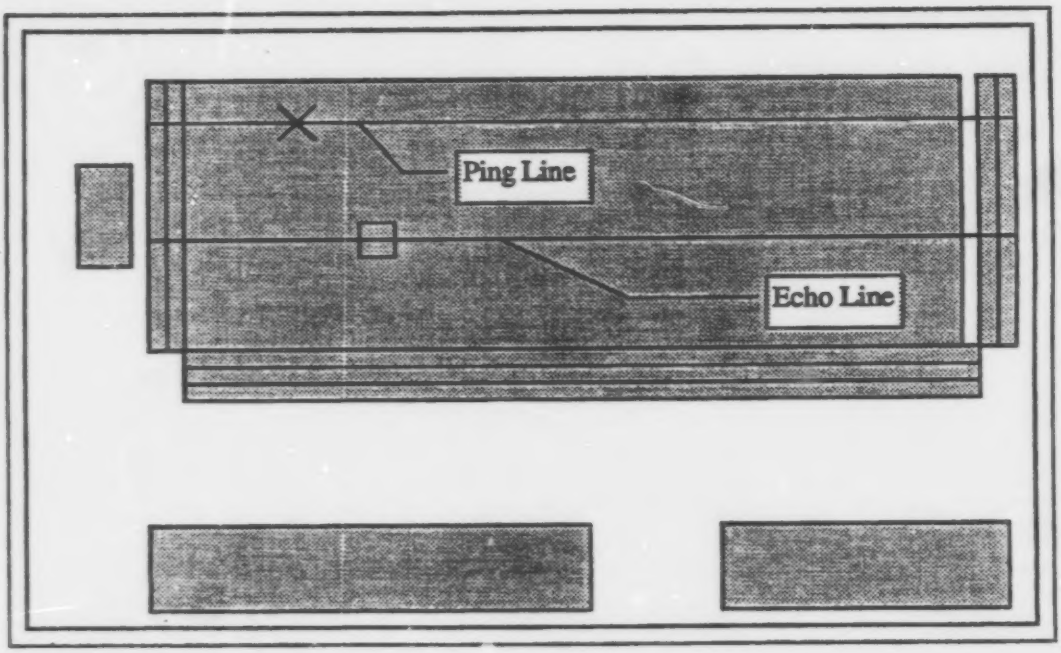


Figure 13-14 Vertical Range Cursor

Figure 13-15 presents the tactical plot format. This format displays geographically referenced symbology representing own ship and other platforms position. Other symbology is displayed representing fix positions. Overlays presenting coastline, bottom depths, clutter and acoustic data can also be displayed. Figure 13-16 presents the monostatic localization tool that is coupled to the offset cursors on the acoustic data formats. Figure 13-17 presents the bistatic localization tool that is coupled to the offset cursors on the acoustic data formats.

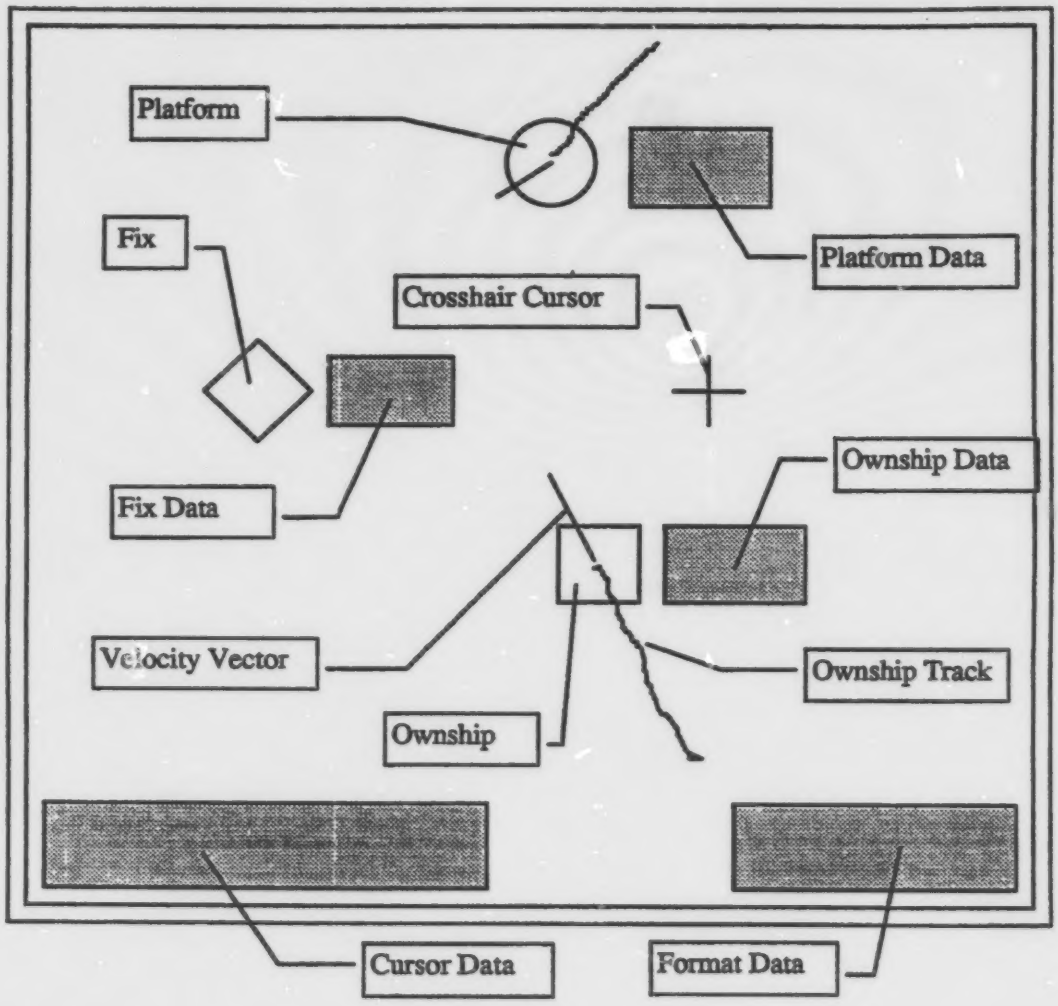


Figure 13-15 Tactical Plot Format

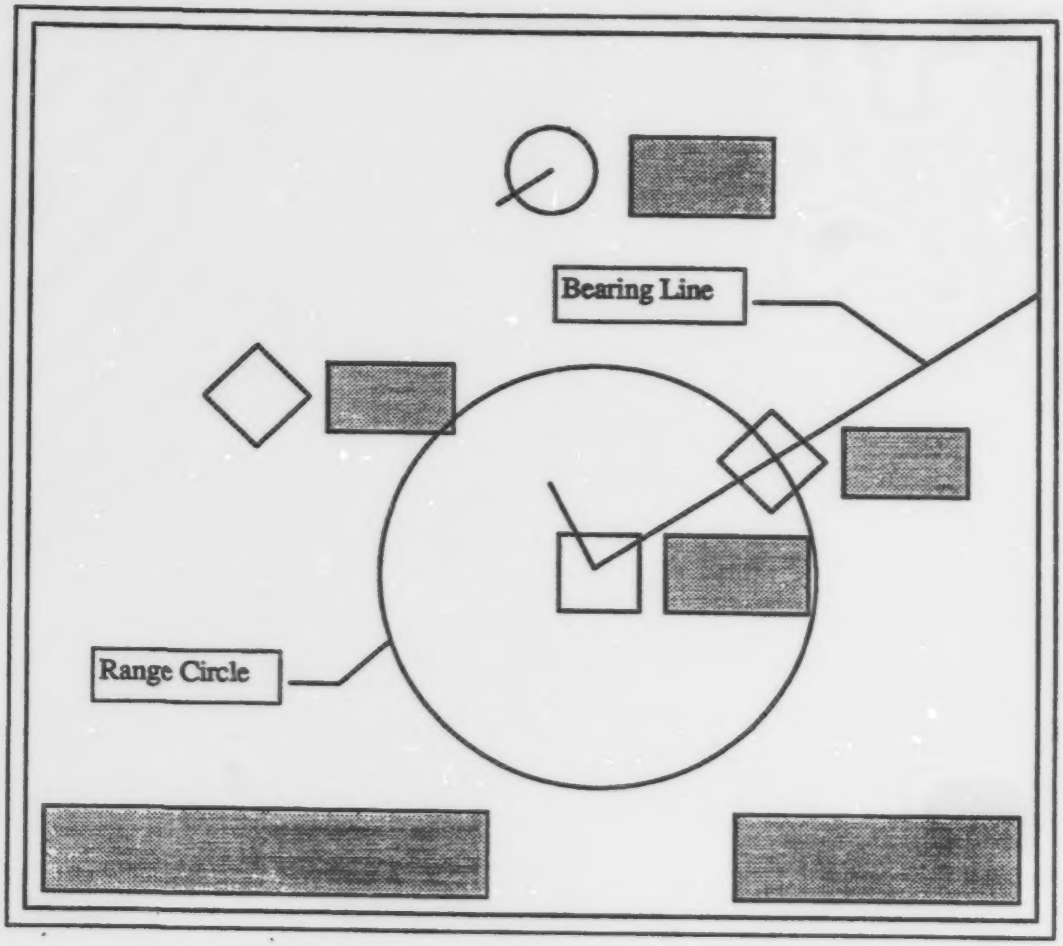


Figure 13-16 Monostatic Localization

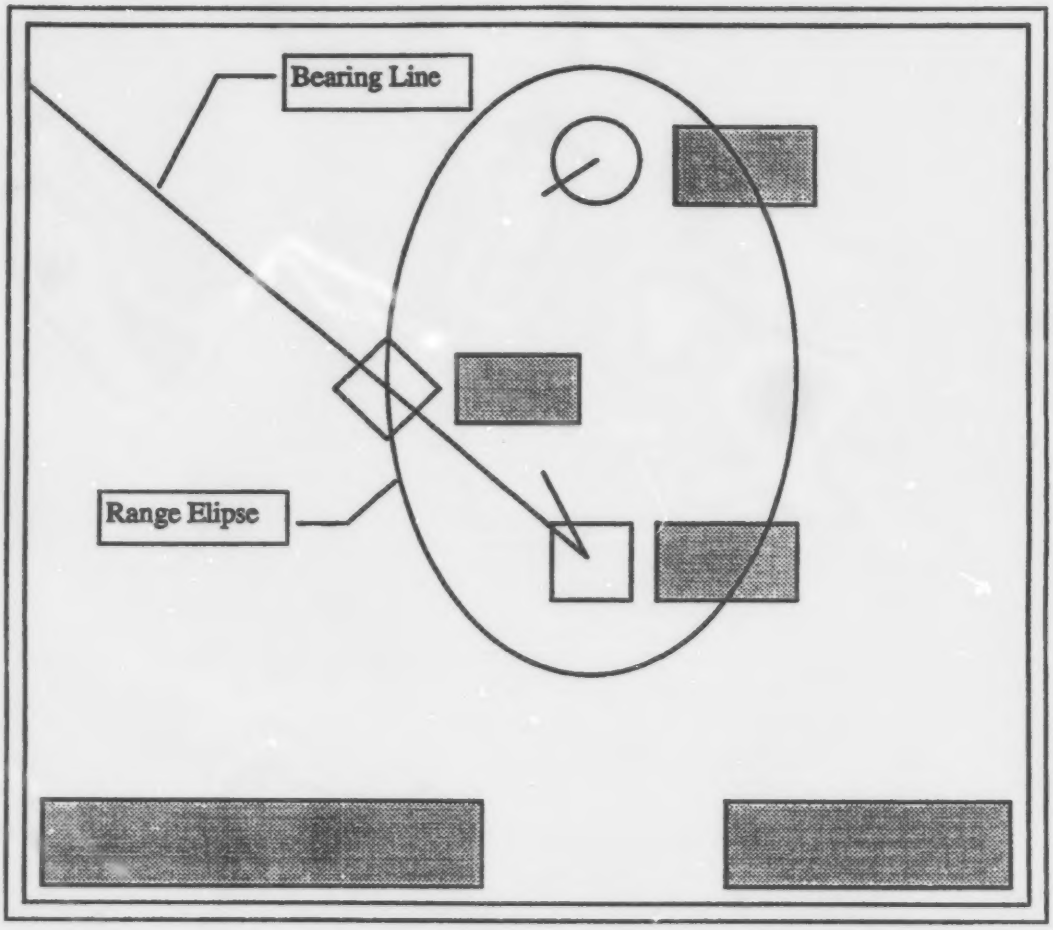


Figure 13-17 Bistatic Localization

14. NGSP Software Benchmarking

This section describes the results of benchmarking the performance of the NGSP. The current version of the IPE is 1.2.4.2. Considerable improvement to the NGSP hardware and the IPE software have resulted in reliable performance of applications on the NGSP. However, at the time of this report an unknown hardware or software optimization problem would result in incorrect results in the ATASA software when the software was compiled optimized and linked with an optimized kernel. The intent is to resolve this problem in the near future. The benchmarks conducted as part of this activity were performed with software optimization turned on and turned off.

The following benchmarks were performed:

- functional performance
  - cache loading
  - working memory to working memory move
  - cache assignment
  - complex multiply
  - complex accumulate
  - complex dot product
  - packed float dual dot product
  - multiple beam beamform
  - single beam beamform
  - FFT
- operating system performance
  - signal and wait
  - vector context
  - CP load startup
  - AP compute startup
  - CP unload startup
- application performance
  - single thread FFT
  - dual thread FFT

The source code for the functional performance benchmarks is presented below.

```
void vector_context_test()

{
  printf( "vector context                    " );
  int cycles = 10000;

  double start_time = clk();
  for ( int i = 0; i < cycles; i++ ) {
    vctx;
  }
  double stop_time = clk() + 0.01;
```

```
  double u = (stop_time-start_time)/(double)cycles;
  printf( "%9.3f\n", 1000.0*u );
}

void fft_test()

{
  printf( "FFT\n" );
  printf( "  Size                  Time(ms) MFLOPS\n" );
  int cycles = 32768*256;
  int k = 1;
  for ( int j = 1; j <= 15; j++ ) {
    k = 2*k;
    double v = 5.0*(float)(j*k);
    {
      vctx;
      pipeMode( PM_STR );
      VCplx V1(k);
      VCplx V2(k);

      double start_time = clk();
      for ( int i = 0; i < cycles; i++ )
        fft( V1, V2 );
      double stop_time = clk() + 0.01;
      double u = (stop_time-start_time)/(double)cycles;
      printf( "%6d              %8.2f %6.1f\n", k, 1000.0*u,
        0.000001*v/u );
    }
    cycles = cycles/2;
  }
}

void complex_multiply_test()

{
  printf( "complex multiply\n" );
  printf( "  Size                  Time(ms) MFLOPS\n" );
  int cycles = 32768*2048;
  for ( int j = 2; j <= 32768; j = 2*j ) {
    {
      vctx;
      pipeMode( PM_STR );
      VCplx V1(j);
      VCplx V2(j);
```

```
        double start_time = clk();
        for ( int i = 0; i < cycles; i++ )
          V2 = V1*V2;
        double stop_time = clk() + 0.01;
        double u = (stop_time-start_time)/(double)cycles;
        double v = 6.0*(float)j;
        printf( "%6d                %9.3f %6.1f\n", j, 1000.0*u,
          0.000001*v/u );
      }
      cycles = cycles/2;
    }
}

void complex_accumulate_test()

{
  printf( "complex accumulate\n" );
  printf( "  Size                Time(ms) MFLOPS\n" );
  int cycles = 32768*2048;
  for ( int j = 2; j <= 32768; j = 2*j ) {
    {
      vctx;
      pipeMode( PM_STR );
      VCplx V1(j);
      SCplx S3;

      double start_time = clk();
      for ( int i = 0; i < cycles; i++ )
        S3 = sum(V1);
      double stop_time = clk() + 0.01;
      double u = (stop_time-start_time)/(double)cycles;
      double v = 2.0*(float)j;
      printf( "%6d                %9.3f %6.1f\n", j, 1000.0*u,
        0.000001*v/u );
    }
    cycles = cycles/2;
  }
}

void complex_dot_product_test()

{
  printf( "complex dot product\n" );
  printf( "  Size                Time(ms) MFLOPS\n" );
  int cycles = 32768*2048;
```

```
  for ( int j = 2; j <= 32768; j = 2*j ) {
    {
      vctx;
      pipeMode( PM_STR );
      VCplx V1(j);
      VCplx V2(j);
      SCplx S3;

      double start_time = clk();
      for ( int i = 0; i < cycles; i++ )
        S3 = sum(V1*V2);
      double stop_time = clk() + 0.01;
      double u = (stop_time-start_time)/(double)cycles;
      double v = 8.0*(float)j;
      printf( "%6d                %9.3f %6.1f\n", j, 1000.0*u,
        0.000001*v/u );
    }
    cycles = cycles/2;
  }
}

void packed_float_dual_dot_product_test()

{
  printf( "packed float dual dot product\n" );
  printf( "  Size                Time(ms) MFLOPS\n" );
  int cycles = 32768*2048;
  for ( int j = 2; j <= 32768; j = 2*j ) {
    {
      vctx;
      pipeMode( PM_STR );
      VPFlt V1(j);
      VPFlt V2(j);
      VPFlt V3(j);
      SPFlt S4;
      SPFlt S5;

      double start_time = clk();
      for ( int i = 0; i < cycles; i++ )
        dual(S4,S5) = sum(mul(darg(V1,V2,V3)));
      double stop_time = clk() + 0.01;
      double u = (stop_time-start_time)/(double)cycles;
      double v = 8.0*(float)j;
      printf( "%6d                %9.3f %6.1f\n", j, 1000.0*u,
        0.000001*v/u );
```

```
    }
    cycles = cycles/2;
  }
}

void cache_memory_loading_test()

{
  printf( "cache loading\n" );
  printf( "  Size                    Time(ms)  MOPS\n" );
  int cycles = 10000;
  for ( int j = 2; j <= 32768; j = 2*j ) {
    VCplx V1(j);
    {
      vctx;
      VCplx V2(j);
      double start_time = clk();
      for ( int i = 0; i < cycles; i++ )
        dtuMove( V1, V2 );
      double stop_time = clk() + 0.01;
      double u = (stop_time-start_time)/(double)cycles;
      double v = 2.0*(float)j;
      printf( "%6d                %9.3f %6.1f\n", j, 1000.0*u,
        0.000001*v/u );
    }
  }
}

void working_memory_move_test()

{
  printf( "working memory move\n" );
  printf( "  Size                    Time(ms)   MOPS\n" );
  int cycles = 10000;
  for ( int j = 2; j <= 32768; j = 2*j ) {
    double v = 2.0*(float)j;
    VCplx V1(j);
    VCplx V2(j);
    {
      vctx;
      double start_time = clk();
      for ( int i = 0; i < cycles; i++ )
        dtuMove( V1, V2 );
      double stop_time = clk() + 0.01;
      double u = (stop_time-start_time)/(double)cycles;
```

```
      printf( "%6d                %9.3f %6.1f\n", j, 1000.0*u,
        0.000001*v/u );
    }
  }
}

void cache_assignment_test()

{
  printf( "cache assignment \n" );
  printf( "  Size                Time(ms) MFLOPS\n" );
  int cycles = 10000;
  for ( int j = 2; j <= 32768; j = 2*j ) {
    double v = 2.0*(float)j;
    {
      vctx;
      VCplx V1(j);
      double start_time = clk();
      for ( int i = 0; i < cycles; i++ )
        V1 = 0;
      double stop_time = clk() + 0.01;
      double u = (stop_time-start_time)/(double)cycles;
      printf( "%6d                %9.3f %6.1f\n", j, 1000.0*u,
        0.000001*v/u );
    }
  }
}

void multiple_beam_beamform_test()

{
  printf( "multibeam beamform without loading\n" );
  printf( "  Size                Time(ms) MFLOPS\n" );
  int cycles = 256*32768;
  for ( int j = 2; j <= 256; j = 2*j ) {
    {
      vctx;
      pipeMode( PM_STR );
      VCplx V1(j);
      VCplx V2(j);

      double start_time = clk();
      for ( int i = 0; i < cycles; i++ )
        bfrm( V1, V2, 0.0, 0.0 );
      double stop_time = clk() + 0.01;
```

```
      double u = (stop_time-start_time)/(double)cycles;
      double v = 8.0*(float)(j*j);
      printf( "%6d                %9.3f %6.1f\n", j, 1000.0*u,
        0.000001*v/u );
    }
    cycles = cycles/2;
  }
}

void single_beam_beamform_test()

{
  printf( "single beam beamform without loading\n" );
  printf( "  Size                Time(ms) MFLOPS\n" );
  int cycles = 256*8192;
  for ( int j = 2; j <= 256; j = 2*j ) {
    double v = 8.0*(float)j;
    {
      vctx;
      pipeMode( PM_STR );
      VCplx V1(j);
      SCplx S2;

      double start_time = clk();
      for ( int i = 0; i < cycles; i++ )
        bfrm( V1, S2, 0.0 );
      double stop_time = clk() + 0.01;
      double u = (stop_time-start_time)/(double)cycles;
      printf( "%6d                %9.3f %6.1f\n", j, 1000.0*u,
        0.000001*v/u );
    }
//    cycles = cycles/2;
  }
}
```

The following tables present the results of the functional performance benchmarks. All time are in milliseconds. The first set of numbers are the performance results for unoptimized software and the second set are for optimized software. MOPS identifies the number of millions 32-bit words transferred per second. MFLOPS identifies the number of millions of 32-bit NGSP floating point operations per second.

Cache loading

Size	Time	MOPS	Time	MOPS
2	0.142	0.0	0.088	0.0
4	0.144	0.1	0.089	0.1

8	0.146	0.1	0.089	0.2
16	0.152	0.2	0.089	0.4
32	0.162	0.4	0.089	0.7
64	0.181	0.7	0.089	1.4
128	0.185	1.4	0.089	2.9
256	0.185	2.8	0.089	5.8
512	0.185	5.5	0.112	9.1
1024	0.218	9.4	0.136	15.1
2048	0.269	15.2	0.183	22.4
4096	0.371	22.1	0.295	27.8
8192	0.589	27.8	0.500	32.8
16384	1.001	32.7	0.919	35.7
32768	2.109	31.1	1.879	34.9

Working memory move

Size	Time	MOPS	Time	MOPS
2	0.150	0.0	0.090	0.0
4	0.154	0.1	0.091	0.1
8	0.155	0.1	0.092	0.2
16	0.161	0.2	0.092	0.3
32	0.172	0.4	0.091	0.7
64	0.188	0.7	0.092	1.4
128	0.189	1.4	0.092	2.8
256	0.189	2.7	0.115	4.5
512	0.223	4.6	0.138	7.4
1024	0.283	7.2	0.205	10.0
2048	0.401	10.2	0.314	13.0
4096	0.701	11.7	0.599	13.7
8192	1.249	13.1	1.123	14.6
16384	2.060	15.9	2.001	16.4
32768	4.667	14.0	4.443	14.8

Assignment

Size	Time	MFLOPS	Time	MFLOPS
2	0.002	2.0	0.002	2.0
4	0.002	4.0	0.002	4.0
8	0.003	5.3	0.003	5.3
16	0.003	10.7	0.003	10.7
32	0.003	21.3	0.003	21.3
64	0.004	32.0	0.004	32.0
128	0.006	42.7	0.006	42.7
256	0.009	56.9	0.009	56.9
512	0.015	68.3	0.015	68.3
1024	0.028	73.1	0.028	73.1
2048	0.054	75.9	0.054	75.9
4096	0.105	78.0	0.105	78.0
8192	0.208	78.8	0.207	79.1
16384	0.413	79.3	0.412	79.5
32768	0.823	79.6	0.822	79.7

Complex multiply

Size	Time	MFLOPS	Time	MFLOPS
2	0.002	7.9	0.001	9.6
4	0.002	15.7	0.001	19.2
8	0.002	31.4	0.001	38.3
16	0.002	62.8	0.001	76.7
32	0.002	125.6	0.001	153.4
64	0.002	239.0	0.002	239.7
128	0.003	239.0	0.003	239.7
256	0.006	239.0	0.006	239.7
512	0.013	239.0	0.013	239.7
1024	0.026	239.7	0.026	239.0
2048	0.051	239.7	0.051	239.7
4096	0.103	239.7	0.103	239.7
8192	0.205	239.7	0.205	239.7
16384	0.410	239.7	0.410	239.7
32768	0.820	239.7	0.820	239.7

Complex accumulate

Size	Time	MFLOPS	Time	MFLOPS
2	0.001	3.3	0.001	4.2
4	0.001	6.7	0.001	8.4
8	0.001	13.3	0.001	16.8
16	0.001	26.6	0.001	33.6
32	0.001	53.2	0.001	67.3
64	0.002	79.7	0.002	79.9
128	0.003	79.7	0.003	79.9
256	0.006	79.7	0.006	79.9
512	0.013	79.7	0.013	79.9
1024	0.026	79.9	0.026	79.9
2048	0.051	79.9	0.051	79.9
4096	0.103	79.9	0.103	79.9
8192	0.205	79.9	0.205	79.9
16384	0.410	79.9	0.410	79.9
32768	0.820	79.9	0.820	79.9

Complex dot product

Size	Time	MFLOPS	Time	MFLOPS
2	0.002	10.5	0.001	13.0
4	0.002	20.9	0.001	26.1
8	0.002	41.9	0.001	52.2
16	0.002	83.8	0.001	104.3
32	0.002	167.5	0.001	208.5
64	0.002	318.6	0.002	319.6
128	0.003	318.6	0.003	319.6
256	0.006	318.6	0.006	319.6
512	0.013	318.6	0.013	319.6
1024	0.026	319.6	0.026	319.6
2048	0.051	319.6	0.051	319.6
4096	0.103	319.6	0.103	319.6
8192	0.205	319.6	0.205	319.6
16384	0.410	319.6	0.410	319.6
32768	0.820	319.6	0.820	319.6

F-2

Packed float dual dot product

Size	Time	MFLOPS	Time	MFLOPS
2	0.002	7.8	0.002	9.3
4	0.002	15.6	0.002	18.5
8	0.002	31.2	0.002	37.1
16	0.002	62.3	0.002	74.1
32	0.002	124.6	0.002	148.1
64	0.002	249.1	0.002	295.8
128	0.003	318.6	0.003	319.6
256	0.006	318.6	0.006	319.6
512	0.013	318.6	0.013	319.6
1024	0.026	319.6	0.026	319.6
2048	0.051	319.6	0.051	319.6
4096	0.103	319.6	0.103	319.6
8192	0.205	319.6	0.205	319.6
16384	0.410	319.6	0.410	319.6
32768	0.820	319.6	0.820	319.6

Multibeam beamform

Size	Time	MFLOPS	Time	MFLOPS
2	0.022	1.4	0.005	6.2
4	0.027	4.8	0.006	20.2
8	0.036	14.2	0.010	53.8
16	0.055	37.3	0.015	140.7
32	0.090	90.7	0.029	283.9
64	0.161	203.4	0.104	314.5
128	0.430	305.0	0.411	319.2
256	1.660	315.8	1.640	319.6

Single beam beamform

Size	Time	MFLOPS	Time	MFLOPS
2	0.015	1.1	0.004	4.3
4	0.016	2.1	0.004	8.6
8	0.015	4.2	0.004	17.2
16	0.016	8.1	0.004	34.5
32	0.015	17.5	0.004	68.8
64	0.020	26.2	0.004	137.9
128	0.020	52.4	0.004	267.3
256	0.020	104.9	0.007	294.9

FFT Size	Time	MFLOPS	Time	MFLOPS
2	0.020	0.5	0.010	2.0
4	0.060	0.7	0.010	7.3
8	0.070	1.8	0.010	18.9
16	0.070	4.6	0.010	45.0
32	0.070	11.1	0.010	102.1
64	0.080	24.3	0.010	181.7
128	0.080	57.2	0.020	293.6
256	0.090	120.1	0.030	358.9
512	0.110	203.5	0.060	387.2
1024	0.180	282.4	0.130	393.8
2048	0.330	339.2	0.280	396.0
4096	0.690	355.7	0.620	397.9
8192	1.460	363.5	1.340	398.0
16384	3.110	369.3	2.870	399.5
32768	6.600	372.3	6.150	399.5

The following tables present the results of the operating system performance benchmarks. All time are in milliseconds. The first column of numbers are the performance results for unoptimized software and the second column are for optimized software.

Thread signal and wait	0.66	0.31
Vector contex	0.21	0.10
CP loads	0.10	0.08
AP computes	0.54	0.38
CP unloads	0.12	0.04

The following tables present the results of the application performance benchmarks. All time are in milliseconds. The first set of numbers are the performance results for unoptimized software and the second set are for optimized software. The vectors column identifies the number of vectors per vector context that were loaded into cache, fast fourier transformed and unloaded from cache.

Single thread FFT

Size	Vectors	Time	MFLOPS	Time	MFLOPS
16	1	1.400	0.2	0.630	0.5
16	2	0.750	0.4	0.330	1.0
16	4	0.420	0.8	0.170	1.9
16	8	0.250	1.3	0.090	3.4
16	16	0.170	1.9	0.050	6.2
16	32	0.120	2.6	0.030	10.9
32	1	1.400	0.6	0.640	1.2

32	2	0.760	1.1	0.330	2.4
32	4	0.430	1.9	0.180	4.5
32	8	0.260	3.0	0.100	8.4
32	16	0.170	4.6	0.050	15.6
32	32	0.130	6.3	0.030	25.2
64	1	1.430	1.3	0.650	2.9
64	2	0.790	2.4	0.350	5.5
64	4	0.450	4.2	0.180	10.6
64	8	0.270	7.1	0.100	19.9
64	16	0.180	10.7	0.060	33.5
64	32	0.140	13.8	0.040	49.2
128	1	1.430	3.1	0.680	6.6
128	2	0.820	5.5	0.360	12.6
128	4	0.450	9.9	0.190	23.8
128	8	0.270	16.6	0.110	41.2
128	16	0.190	24.0	0.070	64.4
128	32	0.150	30.8	0.050	89.5
256	1	1.500	6.8	0.700	14.7
256	2	0.830	12.3	0.370	27.5
256	4	0.460	22.2	0.210	47.7
256	8	0.290	34.8	0.140	74.2
256	16	0.210	49.3	0.100	107.5
256	32	0.160	62.6	0.080	133.2
512	1	1.540	15.0	0.730	31.6
512	2	0.840	27.6	0.430	53.6
512	4	0.510	44.8	0.280	83.5
512	8	0.350	66.2	0.190	120.2
512	16	0.260	88.2	0.160	148.6
512	32	0.220	105.4	0.130	174.8
1024	1	1.610	31.8	0.850	60.1
1024	2	0.990	51.8	0.560	92.2
1024	4	0.630	80.7	0.400	129.1
1024	8	0.470	109.2	0.310	163.2
1024	16	0.380	133.6	0.280	184.8
1024	32	0.360	144.1	0.260	193.3
2048	1	1.880	60.0	1.110	101.4
2048	2	1.250	90.1	0.810	138.6
2048	4	0.890	126.2	0.660	171.8
2048	8	0.720	155.9	0.580	195.5
2048	16	0.670	168.4	0.560	202.8
4096	1	2.500	98.4	1.670	147.5
4096	2	1.790	137.6	1.360	180.2
4096	4	1.460	168.6	1.200	204.2
4096	8	1.350	182.0	1.160	212.4
8192	1	3.640	146.3	2.810	189.5

8192	2	3.000	177.5	2.500	213.0
8192	4	2.780	191.7	2.430	218.9
16384	1	6.180	185.6	5.210	219.9
16384	2	5.750	199.3	5.020	228.4
32768	1	12.000	204.8	10.460	235.0

Dual thread FFT

Size	Vectors	Time	MFLOPS	Time	MFLOPS
16	1	1.440	0.2	0.640	0.5
16	2	0.740	0.4	0.380	0.8
16	4	0.330	1.0	0.210	1.6
16	8	0.190	1.7	0.100	3.1
16	16	0.120	2.6	0.050	6.7
16	32	0.100	3.2	0.030	12.5
32	1	1.430	0.6	0.680	1.2
32	2	0.730	1.1	0.380	2.1
32	4	0.330	2.5	0.200	4.0
32	8	0.190	4.3	0.100	8.0
32	16	0.120	6.4	0.050	16.0
32	32	0.100	7.7	0.030	29.8
64	1	1.410	1.4	0.740	2.6
64	2	0.740	2.6	0.390	4.9
64	4	0.330	5.7	0.210	9.3
64	8	0.190	10.0	0.100	19.0
64	16	0.130	14.7	0.050	37.4
64	32	0.110	17.7	0.030	65.5
128	1	1.470	3.0	0.770	5.8
128	2	0.780	5.7	0.390	11.4
128	4	0.340	13.2	0.200	22.1
128	8	0.200	22.5	0.100	43.2
128	16	0.130	34.3	0.060	79.8
128	32	0.110	41.7	0.040	126.6
256	1	1.540	6.6	0.780	13.1
256	2	0.820	12.5	0.420	24.5
256	4	0.340	30.5	0.210	49.1
256	8	0.200	51.5	0.110	93.2
256	16	0.140	73.6	0.070	149.8
256	32	0.120	87.4	0.050	209.7
512	1	1.560	14.7	0.830	27.6
512	2	0.730	31.4	0.420	54.9
512	4	0.350	65.1	0.210	107.2
512	8	0.230	101.5	0.130	171.6
512	16	0.170	137.8	0.100	242.0
512	32	0.140	160.0	0.080	294.9

1024	1	1.700	30.2	0.820	62.1
1024	2	0.710	71.7	0.430	118.8
1024	4	0.410	125.6	0.270	191.5
1024	8	0.280	181.6	0.180	285.3
1024	16	0.230	218.5	0.160	327.7
1024	32	0.210	241.1	0.150	352.5
2048	1	1.530	73.4	0.860	130.9
2048	2	0.800	141.3	0.520	218.1
2048	4	0.540	209.7	0.370	300.6
2048	8	0.420	265.2	0.330	343.0
2048	16	0.380	292.9	0.310	360.4
4096	1	1.550	158.6	1.000	244.6
4096	2	1.100	223.9	0.790	312.6
4096	4	0.860	286.8	0.700	351.4
4096	8	0.780	314.6	0.670	369.4
8192	1	2.160	246.0	1.670	319.6
8192	2	1.790	298.2	1.500	354.9
8192	4	1.640	325.5	1.430	372.8
16384	1	3.750	305.8	3.190	359.7
16384	2	3.450	332.0	3.050	376.1
32768	1	7.270	337.9	6.500	378.1

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2. SECURITY CLASSIFICATION (overall security classification of the document including special warning terms if applicable).

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ETASS IV (NGSP) Integration Report (U)

4. AUTHORS (Last name, first name, middle initial. If military, show rank, e.g. Doe, Maj. John E.)

Inglis, Gary

5. DATE OF PUBLICATION (month and year of publication of document)

28 July 1998

6a. NO .OF PAGES (total containing information Include Annexes, Appendices, etc).

101

6b. NO. OF REFS (total cited in document)

NIL

7. DESCRIPTIVE NOTES (the category of the document, e.g. technical report, technical note or memorandum. If appropriate, enter the type of report, e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered).

FINAL CONTRACTOR TECHNICAL REPORT

8. SPONSORING ACTIVITY (the name of the department project office or laboratory sponsoring the research and development. Include address).

Defence Research Establishment Atlantic
PO Box 1012, Dartmouth, NS, Canada B2Y 3Z7

9a. PROJECT OR GRANT NO. (if appropriate, the applicable research and development project or grant number under which the document was written. Please specify whether project or grant).

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W7707-6-3467/001/HAL

10a ORIGINATOR'S DOCUMENT NUMBER (the official document number by which the document is identified by the originating activity. This number must be unique to this document.)

TN-6078/003/00

10b OTHER DOCUMENT NOs. (Any other numbers which may be assigned this document either by the originator or by the sponsor.)

DREA CR/98/438

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The NGSP has been under development by DREA for a number of years. The NGSP hardware and software have reached a level in the development where the next step is the evaluation of the NGSP in real applications. This report describes the integration activity undertaken by CDC to integrate the NGSP into two sonar applications. NGSP was successfully integrated into ETASS and ATAS. ETASS is an existing passive towed array sonar system that was developed by DREA and installed on HMCS NIPIGON. ATASA is an active towed array sonar application developed by CDC under contract with DREA. These applications successfully demonstrated the flexibility and performance of the innovative design of the NGSP.

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